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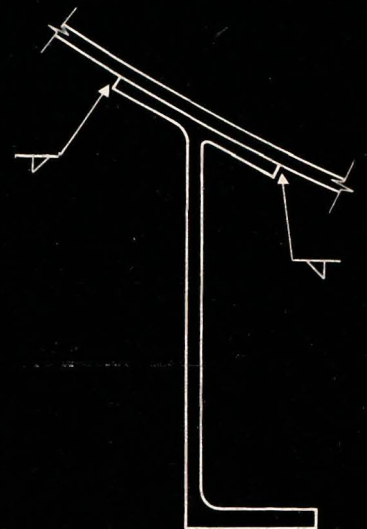
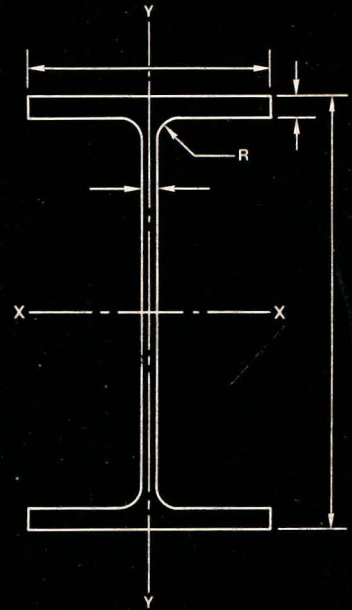
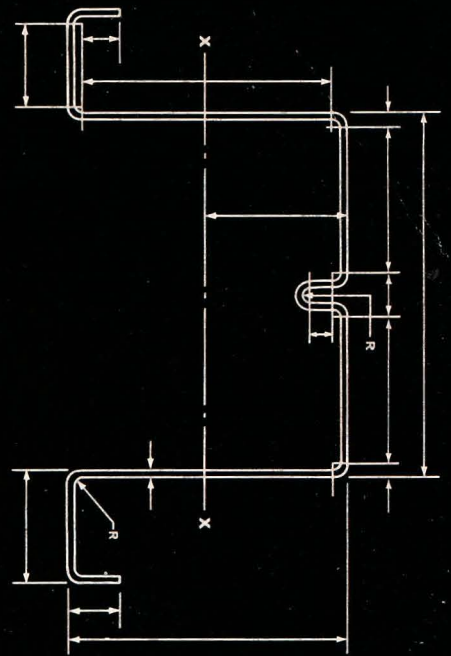
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Aluminum Construction Manual

SPECIFICATIONS FOR ALUMINUM STRUCTURES



THE ALUMINUM ASSOCIATION



ALUMINUM CONSTRUCTION MANUAL

Specifications for Aluminum Structures

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In this second printing, several minor additions and corrections have been made.

Specifically, mechanical properties and buckling constants for alloy 3005-H25 and recently adopted tempers of alclad 3004 sheet have been added to appropriate tables. Temper designations for alloys 2014 and 6061 have been corrected to delete the -T6 temper for plate and add the -T6510 and -T6511 tempers for extrusions. Buckling constants for alloys 5005-H36 and 5052-H36 have been corrected in Table 3.3.1b. In Table 3.3.2 the value of F_{tuw} for 5086-H111 extrusions has been revised from 38 to 35 ksi. Corrections have been made in Table 3.3.6 to replace B_e with B_c in Specification 7, and F_{cy} with F_{sy} in Specifications 20 and 21. In addition, a paragraph has been included on page 47 permitting the use of a weighted average allowable tensile stress for trapezoidal formed sheet beams and an Addendum dealing with alloys not covered in the first printing has been provided beginning on page 62.

FOREWORD

This part of the Aluminum Construction Manual deals with specifications for allowable stresses in structures. It is a compilation of methods for determining allowable stresses based largely on information generated within the aluminum industry.

Much of the material published in these specifications has been previously published in other forms. Some of it is new. It represents the best current thinking of the industry with regard to allowable stress determinations.

We have attempted to present this material in a form that can be widely and generally useful. For this reason commentary has been included with the specifications. It is indented and in smaller type. We will welcome suggestions that users may have regarding the content and form of these specifications.

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ALUMINUM CONSTRUCTION MANUAL

Specifications for Aluminum Structures

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ALUMINUM CONSTRUCTION MANUAL

Specifications for Aluminum Structures

Section 1. General

1.1 Scope. These specifications shall apply to the design of aluminum alloy load carrying members.

1.2 Materials. The principal materials to which these specifications apply are aluminum alloys registered with The Aluminum Association. Those frequently used for structural members are listed in Table 3.3.1, Section 3, with minimum mechanical properties and applicable buckling formula constants. Applicable ASTM specifications are Designations B209, B210, B211, B221, B234, B241, B247, B308, and B429.

1.3 Allowable Stresses.

1.3.1 Building Type Structures. Basic allowable tensile stresses for buildings and similar structures shall be the lesser of the minimum yield strength divided by a factor of safety of 1.65, or the minimum ultimate tensile strength divided by a factor of safety of 1.95. Other allowable stresses for buildings and similar structures shall be based upon the factors of safety shown in Table 3.3.3.

1.3.2 Bridge Type Structures. Basic allowable tensile stresses for bridge type structures shall be the lesser of the minimum yield strength divided by a factor of safety of 1.85, or the minimum ultimate tensile strength divided by a factor of safety of 2.2. Other allowable stresses for bridge and similar structures shall be based upon the factors of safety shown in Table 3.3.3.

*The factors of safety referred to in 1.3.1 and 1.3.2 above are similar to those used in the AISI and AISC specifications and the suggested specifications for aluminum structures of the ASCE Task Committee on Lightweight Alloys. In calculating appropriate stresses for alloys listed in Tables 3.3.7–3.3.27, Section 3, factors of safety for building type structures have been used. Tables for alloys 6061-T6, 6063-T5 and 6063-T6 based on factors of safety for bridge type structures are included in the Appendix.

Section 2. Design Procedure

2.1 Properties of Sections. Properties of sections, such as cross sectional area, moment of inertia, section modulus, radius of gyration, etc. shall be determined in accordance with accepted methods of structural analysis.

* In these specifications indented small type is used to designate explanatory notes or commentary.

2.2 Procedure. Computations for forces, moments, stresses and deflections shall be in accordance with accepted methods of elastic structural analysis and engineering design.

2.3 Loading.

2.3.1 Dead Load. The dead load to be used in the design of the structure is the weight of the structure and all material permanently attached to and supported by the structure.

2.3.2 Live Load. Static and dynamic live loads, as well as snow, ice and wind loads shall be based on appropriate building codes. Where building codes do not apply, requirements shall be established from performance specifications for the structure.

In computing stresses, loads produced by wind and seismic forces acting alone or in combination with dead and live loads may be reduced by 25 percent. However, the section shall not be less than that required for the dead and other live loads acting alone. In the case of wind and ice loads, the form of the structure and any of its exposed components (e.g. increased area exposed to wind due to icing) shall be considered.

Section 3. Allowable Stresses

3.1 Introduction. The nomenclature of terms used in developing the allowable stresses is given in Section 3.2. Minimum mechanical properties and buckling formula constants for each alloy (non-welded material) included in these specifications are listed in Tables 3.3.1a and b. Minimum mechanical properties for welded material are shown in Table 3.3.2.

The allowable stresses for the alloys are determined by applying the appropriate factors of safety to the listed minimum properties and buckling constants. The factors of safety are listed in Table 3.3.3. The formulas for buckling constants are presented in Tables 3.3.4a and b. General formulas for allowable stresses are given in Table 3.3.6. An explanation of these formulas is presented in Section 3.4. The last number of each paragraph designation in Section 3.4 corresponds to the Specification no. of Tables 3.3.6 to 3.3.27, e.g. 3.4.12 refers to Specification no. 12. Allowable stresses for some alloys to be used in buildings and similar structures have been determined in accordance with these procedures. They are presented in Tables 3.3.7 to 3.3.27. For bridge and similar type structures see Appendix.

allowable stresses/nomenclature

3.2 Nomenclature

English units are used throughout these specifications. *Ksi* indicates thousands of pounds per square inch; kips indicates thousands of pounds.

A	= Area, in ² .	F_{ec}	= $\pi^2 E / [n_u (L/r)^2]$, where L/r is slenderness ratio for member considered as a column tending to fail in the plane of the applied bending moments, ksi
A_w	= Area of cross section lying within 1.0 in. of a weld, in ² .	F_n	= allowable stress for cross section 1.0 in. or more from weld, ksi
a_1	= shorter dimension of rectangular panel, in.	F_{pw}	= allowable stress on cross section, part of whose area lies within 1.0 in. of a weld, ksi
a_2	= longer dimension of rectangular panel, in.	F_s	= allowable shear stress for members subjected only to torsion or shear, ksi
a_e	= equivalent width of rectangular panel, in.	F_{su}	= shear ultimate strength, ksi
B, D, C	= buckling formula constants, with following subscript:	F_{suw}	= shear ultimate strength within 1.0 in. of a weld, ksi
	c — compression in columns	F_{sy}	= shear yield strength, ksi
	p — compression in flat plates	F_{syw}	= shear yield strength within 1.0 in. of a weld, ksi
	t — compression in round tubes	F_{tu}	= tensile ultimate strength, ksi
	tb — bending in round tubes	F_{tuw}	= tensile ultimate strength across a butt weld, ksi
	b — bending in rectangular bars	F_{ty}	= tensile yield strength, ksi
	s — shear in flat plates	F_{tyw}	= tensile yield strength across a butt weld (0.2 percent offset in 10-in. gage length), ksi
b	= width of sections, in.	F_y	= either F_{ty} or F_{cy} , whichever is smaller, ksi
b/t	= width to thickness ratio of rectangular element of a cross section	g	= spacing of rivet or bolt holes perpendicular to direction of load, in.
c	= distance from neutral axis to extreme fiber, in.	G	= modulus of elasticity in shear, ksi
D	= diameter, in.	h	= clear height of shear web, in.
d	= depth of section or beam, in.	I	= moment of inertia, in. ⁴
E	= compressive modulus of elasticity, ksi	I_h	= moment of inertia of horizontal stiffener, in. ⁴
f	= calculated stress, ksi	I_s	= moment of inertia of transverse stiffener to resist shear buckling, in. ⁴
f_a	= average compressive stress on cross section of member produced by axial compressive load, ksi	I_x	= moment of inertia of a beam about axis perpendicular to web, in. ⁴
f_b	= maximum bending stress (compression) caused by transverse loads or end moments, ksi	I_y	= moment of inertia of a beam about axis parallel to web, in. ⁴
f_s	= shear stress caused by torsion or transverse shear, ksi	J	= torsion constant, in. ⁴
F	= allowable stress, ksi	k_1	= coefficient for determining slenderness limit S_2 for sections for which the allowable compressive stress is based on crippling strength.
F_a	= allowable compressive stress for member considered as an axially loaded column, ksi	k_2	= coefficient for determining allowable compressive stress in sections with slenderness ratio above S_2 for which the allowable compressive stress is based on crippling strength.
F_b	= allowable compressive stress for member considered as a beam, ksi	k_c	= coefficient for compression members.
F_{bu}	= bearing ultimate strength, ksi	k_t	= coefficient for tension members.
F_{buw}	= bearing ultimate strength within 1.0 in. of a weld, ksi	L	= length of compression member between points of lateral support, or twice the length of a cantilever column (except where analysis shows that a shorter length can be used), in.
F_{by}	= bearing yield strength, ksi	L/r	= slenderness ratio for columns
F_{byw}	= bearing yield strength within 1.0 in. of a weld, ksi		
F_c	= allowable compressive stress, ksi		
F_{cy}	= compressive yield strength, ksi		
F_{cyw}	= compressive yield strength across a butt weld (0.2 percent offset in 10 in. gage length), ksi		

nomenclature/allowable stresses

L_b = length of beam between points at which the compression flange is supported against lateral movement, or length of cantilever beam from free end to point at which the compression flange is supported against lateral movement, in.
 L_h = total length of portion of column lying within 1.0 in. of a weld (excluding welds at ends of columns that are supported at both ends), in.
 L_w = increased length to be substituted in column formula to determine allowable stress for welded column, in.
 M = bending moment, in.-kips.
 M_c = bending moment at center of span resulting from applied bending loads, in.-kips.
 M_m = maximum bending moment in span resulting from applied bending loads, in.-kips.
 M_1, M_2 = bending moments at two ends of a beam, in.-kips.
 n_a = factor of safety on appearance of buckling
 n_u = factor of safety on ultimate strength
 n_y = factor of safety on yield strength
 P = local load concentration on bearing stiffener, kips.
 r = least radius of gyration of a column, in.
 r_L = radius of gyration of lip or bulb about face of flange from which lip projects, in.
 r_y = radius of gyration of a beam (about axis parallel to web), in. (For beams that are unsymmetrical about the horizontal axis, r_y should be calculated as though both flanges were the same as the compression flange.)
 R = outside radius of round tube or maximum outside radius for an oval tube, in.
 R_b = radius of curvature of tubular members, in.
 s = spacing of transverse stiffeners (clear distance between stiffeners for stiffeners consisting of a pair of members, one on each side of the web, center-to-center distance between stiffeners consisting of a member on one side of the web only), in.; spacing of rivet or bolt holes parallel to direction of load, in.
 S_c = section modulus of a beam, compression side, in.³
 S_t = section modulus of a beam, tension side, in.³
 S_1, S_2 = slenderness limits (see Table 3.3.6)
 t = thickness of flange, plate, web or tube, in. (For tapered flanges, t is the average thickness.)
 V = shear force on web at stiffener location, kips

α = a factor equal to unity for a stiffener consisting of equal members on both sides of the web and equal to 3.5 for a stiffener consisting of a member on one side only

3.3 Tables Relating To Allowable Stresses

Section 3.3 consists of tables concerning formulas for determining allowable stresses and constants and coefficients needed for these formulas. It also includes tables applicable to those alloys and tempers that should be of most use in designing aluminum structures. These tables are:

3.3.1a Minimum Mechanical Properties For Aluminum Alloys

3.3.1b Buckling Formula Constants For Aluminum Alloys

3.3.2 Minimum Mechanical Properties, Welded Aluminum Alloys

3.3.3 Factors of Safety For Use With Aluminum Allowable Stress Specifications

3.3.4a Formulas For Buckling Constants—For all products whose temper designation begins with -O, -H, -T1, -T2, -T3, or -T4

3.3.4b Formulas For Buckling Constants—For products whose temper designation begins with -T5, -T6, -T7, -T8, or -T9

3.3.5 Values of Coefficients k_t and k_c

3.3.6 General Formulas For Determining Allowable Stresses

Allowable Stresses for Building Structures of

3.3.7 Alloy 1100-H14

3.3.8 Alloy 2014-T6, -T651

3.3.9 Alloy 3003-H14

3.3.10 Alloy 3003-H16

3.3.11 Alclad 3004-H16

3.3.12 Alclad 3004-H34

3.3.13 Alloy 5005-H14

3.3.14 Alloy 5050-H34

3.3.15 Alloy 5052-H34

3.3.16 Alloy 5083-H111 Extrusions

3.3.17 Alloy 5083-H321 Sheet & Plate

3.3.18 Alloy 5086-H111 Extrusions

3.3.19 Alloy 5086-H34

3.3.20 Alloy 5454-H111 Extrusions

3.3.21 Alloy 5454-H34 Sheet & Plate

3.3.22 Alloy 5456-H111 Extrusions

3.3.23 Alloy 5456-H321 Sheet & Plate

3.3.24 Alloy 5456-H343

3.3.25 Alloy 6061-T6, -T651

3.3.26 Alloy 6063-T5 Extrusions

3.3.27 Alloy 6063-T6 Extrusions

Tables of allowable stresses for bridge and similar type structures are given in the Appendix for alloys 6061 and 6063.

TABLE 3.3.1a
MINIMUM MECHANICAL PROPERTIES
FOR ALUMINUM ALLOYS

Values Are Given in Units of ksi (1000 lb/in²)

Alloy And Temper	Product*	Thickness Range* in.	TENSION		COM- PRES- SION <i>F_{cy}</i> ksi	SHEAR		BEARING		Compressive Modulus of Elasticity† <i>E</i> ksi
			<i>F_{tu}</i> † ksi	<i>F_{ty}</i> † ksi		<i>F_{su}</i> ksi	<i>F_{sy}</i> ksi	<i>F_{bu}</i> ksi	<i>F_{by}</i> ksi	
1100-H12 -H14	(Sheet, Plate Rolled Rod & Bar Drawn Tube)	All	14	11	10	9	6.5	28	18	10,100
		All	16	14	13	10	8	32	21	10,100
2014-T6 -T651 -T6,T6510** -T6,T651	Sheet	0.040-0.249	66	58	59	40	33	125	93	10,900
	Plate	0.250-2.000	67	59	58	40	34	127	94	10,900
	Extrusions	All	60	53	55	35	31	114	85	10,900
	Rolled Rod & Bar Drawn Tube	All	65	55	53	38	32	124	88	10,900
Alclad 2014-T6 -T6 -T651	Sheet	0.020-0.039	63	55	56	38	32	120	88	10,800
	Sheet	0.040-0.249	64	57	58	39	33	122	91	10,800
	Plate	0.250-0.499	64	57	56	39	33	122	91	10,800
3003-H12 -H14 -H16 -H18	Sheet & Plate	0.017-2.000	17	12	10	11	7	34	19	10,100
	Sheet & Plate	0.009-1.000	20	17	14	12	10	40	25	10,100
	Sheet	0.006-0.162	24	21	18	14	12	46	31	10,100
	Sheet	0.006-0.128	27	24	20	15	14	49	34	10,100
3003-H12 -H14 -H16 -H18	Drawn Tube	All	17	12	10	11	7	34	19	10,100
	Drawn Tube	All	20	17	16	12	10	40	25	10,100
	Drawn Tube	All	24	21	19	14	12	46	31	10,100
	Drawn Tube	All	27	24	21	15	14	49	34	10,100
Alclad 3003-H12 -H14 -H16 -H18	Sheet & Plate	0.017-2.000	16	11	9	10	6.5	32	18	10,100
	Sheet & Plate	0.009-1.000	19	16	13	12	9	38	24	10,100
	Sheet	0.006-0.162	23	20	17	14	12	44	30	10,100
	Sheet	0.006-0.128	26	23	19	15	13	47	32	10,100
Alclad 3003-H14 -H18	Drawn Tube	0.010-0.500	19	16	15	12	9	38	24	10,100
	Drawn Tube	0.010-0.500	26	23	20	15	13	47	32	10,100
3004-H32 -H34 -H36	Sheet & Plate	0.017-2.000	28	21	18	17	12	56	36	10,100
	Sheet & Plate	0.009-1.000	32	25	22	19	14	64	40	10,100
	Sheet	0.006-0.162	35	28	25	20	16	70	45	10,100
3004-H34 -H36	Drawn Tube	0.018-0.450	32	25	24	19	14	64	40	10,100
	Drawn Tube	0.018-0.450	35	28	27	20	16	70	45	10,100
Alclad 3004-H32 -H34 -H36 -H14 -H16 -H131,H241,H341 -H151,H261,H361	Sheet	0.017-0.249	27	20	17	16	12	54	34	10,100
	Sheet	0.009-0.249	31	24	21	18	14	62	38	10,100
	Sheet	0.006-0.162	34	27	24	19	16	68	43	10,100
	Sheet	0.009-0.249	32	26	22	19	15	64	39	10,100
	Sheet	0.006-0.162	35	30	26	20	17	66	45	10,100
	Sheet	0.024-0.050	31	26	22	18	15	62	39	10,100
	Sheet	0.024-0.050	34	30	26	19	17	66	45	10,100
3005-H25	Sheet	0.013-0.050	26	22	20	15	13	49	35	10,100
5005-H12 -H14 -H16 -H32 -H34 -H36	Sheet & Plate	0.018-2.000	18	14	13	11	8	34	22	10,100
	Sheet & Plate	0.009-1.000	21	17	15	12	10	40	25	10,100
	Sheet	0.006-0.162	24	20	18	14	12	48	30	10,100
	Sheet & Plate	0.017-2.000	17	12	11	11	7	34	20	10,100
	Sheet & Plate	0.009-1.000	20	15	14	12	8.5	40	24	10,100
	Sheet	0.006-0.162	23	18	16	13	11	48	29	10,100

TABLE 3.3.1a (cont'd)

Alloy And Temper	Product*	Thickness Range* in.	TENSION		COM- PRES- SION F_{cy} ksi	SHEAR		BEARING		Compressive Modulus of Elasticity† E ksi
			$F_{tu}†$ ksi	$F_{ty}†$ ksi		F_{su} ksi	F_{sy} ksi	F_{bu} ksi	F_{by} ksi	
5050-H32	Sheet	0.017-0.249	22	16	14	14	9	44	27	10,100
-H34	Sheet	0.009-0.249	25	20	18	15	12	50	32	10,100
-H32	Rolled Rod & Bar	All	22	16	15	13	9	44	27	10,100
-H34	Drawn Tube									
-H34	Rolled Rod & Bar	All	25	20	19	15	12	50	32	10,100
-H34	Drawn Tube									
5052-H32	(Sheet & Plate	All	31	23	21	19	13	60	39	10,200
-H34	Rolled Rod & Bar)	All	34	26	24	20	15	65	44	10,200
-H36	Drawn Tube									
-H36	Sheet	0.006-0.162	37	29	26	22	17	70	46	10,200
5083-H111	Extrusions	up thru 0.500	40	24	21	24	14	78	41	10,400
-H111	Extrusions	0.501 and over	40	24	21	23	14	78	38	10,400
-H321	Sheet & Plate	0.188-1.500	44	31	26	26	18	84	53	10,400
-H323	Sheet	0.051-0.249	45	34	32	26	20	88	58	10,400
-H343	Sheet	0.051-0.249	50	39	37	29	23	95	66	10,400
-H321	Plate	1.501-3.000	41	29	24	24	17	78	49	10,400
5086-H111	Extrusions	up thru 0.500	36	21	18	21	12	70	36	10,400
-H111	Extrusions	0.501 and over	36	21	18	21	12	70	34	10,400
-H112	Plate	0.250-0.499	36	18	17	22	10	72	31	10,400
-H112	Plate	0.500-1.000	35	16	16	21	9	70	28	10,400
-H112	Plate	1.001-2.000	35	14	15	21	8	70	28	10,400
-H112	Plate	2.001-3.000	34	14	15	21	8	68	28	10,400
-H32	(Sheet & Plate)	All	40	28	26	24	16	78	48	10,400
-H34	Drawn Tube)	All	44	34	32	26	20	84	58	10,400
5454-H111	Extrusions	up thru 0.500	33	19	16	20	11	64	32	10,400
-H111	Extrusions	0.501 and over	33	19	16	19	11	64	30	10,400
-H112	Extrusions	up thru 5.000	31	12	13	19	7	62	24	10,400
-H32	Sheet & Plate	0.020-2.000	36	26	24	21	15	70	44	10,400
-H34	Sheet & Plate	0.020-1.000	39	29	27	23	17	74	49	10,400
5456-H111	Extrusions	up thru 0.500	42	26	22	25	15	82	44	10,400
-H111	Extrusions	0.501 and over	42	26	22	24	15	82	42	10,400
-H112	Extrusions	up thru 5.000	41	19	20	24	11	82	38	10,400
-H321	Sheet & Plate	0.188-1.250	46	33	27	27	19	87	56	10,400
-H321	Plate	1.251-1.500	44	31	25	25	18	84	53	10,400
-H321	Plate	1.501-3.000	41	29	25	25	17	82	49	10,400
-H323	Sheet	0.051-0.249	48	36	34	28	21	94	61	10,400
-H343	Sheet	0.051-0.249	53	41	39	31	24	101	70	10,400
6061-T6,T651	Sheet & Plate	0.010-4.000	42	35	35	27	20	88	58	10,100
-T6,T651**	Extrusions	up thru 3.000	38	35	35	24	20	80	56	10,100
-T6,T651	Rolled Rod & Bar	up thru 8.000	42	35	35	27	20	88	56	10,100
-T6	Drawn Tube	0.025-0.500	42	35	35	27	20	88	56	10,100
-T6	Pipe	up thru 0.999	42	35	35	27	20	88	56	10,100
-T6	Pipe	over 0.999	38	35	35	24	20	80	56	10,100
6063-T5	Extrusions	up thru 0.500	22	16	16	13	9	46	26	10,100
-T5	Extrusions	over 0.500	21	15	15	12	8.5	44	24	10,100
-T6	Extrusions	All	30	25	25	19	14	63	40	10,100

* Most product and thickness ranges are taken from The Aluminum Association's 1968-1969 edition of "Aluminum Standards and Data."

† F_{tu} and F_{ty} are minimum specified values (except for Alclad 3004-H14, -H16 and F_{ty} for Alclad 3003-H18) other strength properties are corresponding minimum expected values.

‡ For deflection calculations an average modulus of elasticity is used; numerically this is 100 ksi lower than the values in this column.

** Values also apply to -T6511 temper.

TABLE 3.3.1b
BUCKLING FORMULA CONSTANTS FOR ALUMINUM ALLOYS

Alloy And Temper	Product	COMPRESSION IN COLUMNS			COMPRESSION IN FLAT PLATES			COMPRESSION IN ROUND TUBES			BENDING IN ROUND TUBES			BENDING IN REC- TANGULAR BARS			SHEAR IN FLAT PLATES		
		B_c ksi	D_c ksi	C_c	B_p ksi	D_p ksi	C_p	B_t ksi	D_t ksi	C_t	B_{rb} ksi	D_{rb} ksi	C_{rb}	B_b ksi	D_b ksi	C_b	B_s ksi	D_s ksi	C_s
1100-H12 -H14	(Sheet, Plate) Rolled Rod Drawn Tube	11.0	0.044	165	12.8	0.056	153	12.7	0.372	607	19.1	0.875	160	17.0	0.085	133	8.5	0.030	188
		14.5	0.067	144	17.0	0.086	133	16.7	0.536	461	25.1	1.260	133	22.6	0.131	115	10.6	0.042	168
2014-T6 -T651 -T6,T6510** -T6,T651	Sheet	68.6	0.544	52	79.1	0.674	48	74.3	3.132	94	109.5	8.754	39	119.4	1.530	52	44.4	0.283	64
	Plate	67.3	0.529	52	77.7	0.656	48	73.0	3.059	95	109.5	8.754	41	117.1	1.486	53	45.8	0.297	63
	Extrusions	63.6	0.486	54	73.3	0.602	50	69.1	2.841	100	99.7	7.724	39	110.3	1.360	54	41.5	0.256	66
	Rolled Bar Drawn Tube	61.1	0.458	55	70.5	0.567	51	66.5	2.699	103	99.7	7.724	44	105.9	1.278	55	42.9	0.269	65
Alclad 2014-T6 -T6 -T651	Sheet (0.039)*	64.8	0.502	53	74.8	0.622	49	70.4	2.922	98	103.6	8.157	40	112.6	1.408	53	42.9	0.271	65
	Sheet (0.249)*	67.3	0.531	52	77.7	0.659	48	73.0	3.068	94	107.6	8.571	39	117.1	1.493	52	44.4	0.285	64
	Plate	64.8	0.502	53	74.8	0.622	49	70.4	2.922	98	105.6	8.363	42	112.6	1.408	53	44.4	0.285	64
3003-H12 -H14 -H16 -H18	Sheet & Plate	11.0	0.044	165	12.8	0.056	153	12.7	0.372	607	19.1	0.875	160	17.0	0.085	133	9.2	0.034	181
	Sheet & Plate	15.7	0.075	138	18.4	0.096	127	18.1	0.594	415	27.1	1.397	127	24.5	0.147	111	13.5	0.060	149
	Sheet	20.4	0.112	121	24.2	0.145	111	23.5	0.843	330	35.3	1.984	106	32.2	0.222	97	16.4	0.081	135
	Sheet	22.8	0.133	115	27.1	0.172	105	26.3	0.977	294	39.4	2.298	99	36.1	0.264	91	19.4	0.104	124
3003-H12 -H14 -H16 -H18	Drawn Tube	12.2	0.052	157	14.2	0.065	145	14.1	0.424	506	21.1	0.999	150	18.8	0.100	126	9.2	0.034	181
	Drawn Tube	18.0	0.093	129	21.3	0.120	119	20.8	0.715	365	31.2	1.683	115	28.3	0.183	103	13.5	0.060	149
	Drawn Tube	21.6	0.123	118	25.7	0.159	108	24.9	0.909	310	37.4	2.140	102	34.1	0.243	94	16.4	0.081	135
	Drawn Tube	24.0	0.144	112	28.6	0.187	102	27.7	1.046	279	41.5	2.461	96	38.1	0.286	89	19.4	0.104	124
Alclad 3003-H12 -H14 -H16 -H18	Sheet & Plate	9.9	0.038	174	11.5	0.047	162	11.4	0.321	640	17.1	0.756	172	15.2	0.072	140	8.5	0.030	188
	Sheet & Plate	14.5	0.067	144	17.0	0.086	133	16.7	0.536	461	25.1	1.260	133	22.6	0.131	115	12.0	0.051	158
	Sheet	19.2	0.103	125	22.8	0.132	115	22.2	0.779	342	33.2	1.832	111	30.2	0.202	100	16.4	0.081	135
	Sheet	21.6	0.123	118	25.7	0.159	108	24.9	0.909	310	37.4	2.140	102	34.1	0.243	94	17.9	0.093	129
Alclad 3003-H14 -H18	Drawn Tube	16.8	0.084	133	19.9	0.108	123	19.4	0.654	398	29.2	1.538	121	26.4	0.165	107	12.0	0.051	158
	Drawn Tube	22.8	0.133	115	27.1	0.172	105	26.3	0.977	294	39.4	2.298	99	36.1	0.264	91	17.9	0.093	129
3004-H32 -H34 -H36	Sheet & Plate	20.4	0.112	121	24.2	0.145	111	23.5	0.843	330	35.3	1.984	106	32.2	0.222	97	16.4	0.081	135
	Sheet & Plate	25.3	0.155	109	30.1	0.201	100	29.0	1.116	271	43.6	2.626	92	40.0	0.309	86	19.4	0.104	124
	Sheet	29.0	0.190	102	34.6	0.248	93	33.2	1.334	237	49.8	3.140	85	46.1	0.381	81	22.5	0.130	115
3004-H34 -H36	Drawn Tube	27.7	0.178	104	33.1	0.232	95	31.8	1.260	247	47.7	2.966	87	44.1	0.356	82	19.4	0.104	124
	Drawn Tube	31.4	0.215	98	37.7	0.282	89	36.0	1.486	220	54.0	3.497	80	50.1	0.433	77	22.5	0.130	115
Alclad 3004-H32 -H34 -H36 -H14 -H16 -H131,H241,H341 -H151,H261,H361	Sheet	19.2	0.103	125	22.8	0.132	115	22.2	0.779	342	33.2	1.832	111	30.2	0.202	100	16.4	0.081	135
	Sheet	24.0	0.144	112	28.6	0.187	102	27.7	1.046	279	41.5	2.461	96	38.1	0.286	89	19.4	0.104	124
	Sheet	27.7	0.178	104	33.1	0.232	95	31.8	1.260	247	47.7	2.966	87	44.1	0.356	82	22.5	0.130	115
	Sheet	25.3	0.155	109	30.1	0.201	100	29.0	1.116	271	43.6	2.626	92	40.0	0.309	86	21.0	0.117	120
	Sheet	30.2	0.202	100	36.1	0.265	91	34.6	1.410	229	51.9	3.317	82	48.1	0.407	79	24.1	0.144	112
	Sheet	25.3	0.155	109	30.1	0.201	100	29.0	1.116	271	43.6	2.626	92	40.0	0.309	86	21.0	0.117	120
	Sheet	30.2	0.202	100	36.1	0.265	91	34.6	1.410	229	51.9	3.317	82	48.1	0.407	79	24.1	0.144	112
	Sheet	25.3	0.155	109	30.1	0.201	100	29.0	1.116	271	43.6	2.626	92	40.0	0.309	86	21.0	0.117	120
3005-H25	Sheet	22.8	0.133	115	27.1	0.172	105	26.3	0.977	294	39.4	2.298	99	36.1	0.264	91	17.9	0.093	129
5005-H12 -H14 -H16 -H32 -H34 -H36	Sheet & Plate	14.5	0.067	144	17.0	0.086	133	16.7	0.536	461	25.1	1.260	133	22.6	0.131	115	10.6	0.042	168
	Sheet & Plate	16.8	0.084	133	19.9	0.108	123	19.4	0.654	398	29.2	1.538	121	26.4	0.165	107	13.5	0.060	149
	Sheet	20.4	0.112	121	24.2	0.145	111	23.5	0.843	330	35.3	1.984	106	32.2	0.222	97	16.4	0.081	135
	Sheet & Plate	12.2	0.052	157	14.2	0.065	145	14.1	0.424	506	21.1	0.999	150	18.8	0.100	126	9.2	0.034	181
	Sheet & Plate	15.7	0.075	138	18.4	0.096	127	18.1	0.594	415	27.1	1.397	127	24.5	0.147	111	11.3	0.046	163
	Sheet	18.0	0.093	129	21.3	0.120	119	20.8	0.715	365	31.2	1.683	115	28.3	0.183	103	14.9	0.070	142

*Maximum thickness indicated in parentheses. See Table 3.3.1a for corresponding thickness range.

TABLE 3.3.1b (cont'd)
BUCKLING FORMULA CONSTANTS FOR ALUMINUM ALLOYS

Alloy And Temper	Product	COMPRESSION IN COLUMNS			COMPRESSION IN FLAT PLATES			COMPRESSION IN ROUND TUBES			BENDING IN ROUND TUBES			BENDING IN REC- TANGULAR BARS			SHEAR IN FLAT PLATES		
		B_c ksi	D_c ksi	C_c	B_p ksi	D_p ksi	C_p	B_t ksi	D_t ksi	C_t	B_{tb} ksi	D_{tb} ksi	C_{tb}	B_b ksi	D_b ksi	C_b	B_s ksi	D_s ksi	C_s
5050-H32	Sheet	15.7	0.075	138	18.4	0.096	127	18.1	0.594	415	27.1	1.397	127	24.5	0.147	111	12.0	0.051	158
-H34	Sheet	20.4	0.112	121	24.2	0.145	111	23.5	0.843	330	35.3	1.984	106	32.2	0.222	97	16.4	0.081	135
-H32	Rolled Bar	16.8	0.084	133	19.9	0.108	123	19.4	0.654	398	29.2	1.538	121	26.4	0.165	107	12.0	0.051	158
-H34	Drawn Tube	21.6	0.123	118	25.7	0.159	108	24.9	0.909	310	37.4	2.140	102	34.1	0.243	94	16.4	0.081	135
5052-H32	(Sheet & Plate)	24.0	0.143	112	28.6	0.186	103	27.7	1.042	281	41.5	2.453	96	38.1	0.285	89	17.9	0.092	130
-H34	(Rolled Rod)	27.7	0.177	104	33.1	0.231	96	31.8	1.256	250	47.7	2.956	88	44.1	0.355	83	21.0	0.116	120
-H36	Drawn Tube	30.2	0.201	100	36.1	0.263	91	34.6	1.405	230	51.9	3.306	83	48.1	0.405	79	24.1	0.143	112
5083-H111	Extrusions (All)	24.0	0.142	113	28.6	0.184	104	27.7	1.036	286	41.5	2.437	97	38.1	0.282	90	19.4	0.103	126
-H321	Sheet & Plate (1.500)*	30.2	0.199	101	36.1	0.261	92	34.6	1.396	235	51.9	3.285	84	48.1	0.401	80	25.6	0.156	110
-H323	Sheet	37.7	0.278	90	45.5	0.367	82	43.0	1.867	192	64.6	4.394	73	60.5	0.565	71	28.8	0.185	104
-H343	Sheet	44.1	0.352	84	53.2	0.466	76	50.1	2.289	166	75.2	5.386	66	71.0	0.718	66	33.5	0.233	96
-H321	Plate (3.000)*	27.7	0.175	105	33.1	0.229	97	31.8	1.248	254	47.7	2.937	89	44.1	0.351	84	24.1	0.142	113
5086-H111	Extrusions (All)	20.4	0.111	123	24.2	0.143	113	23.5	0.835	339	35.3	1.965	108	32.2	0.219	98	16.4	0.080	137
-H112	Plate (0.500)*	19.2	0.101	127	22.8	0.130	116	22.2	0.771	351	33.2	1.814	113	30.2	0.199	101	13.5	0.059	151
-H112	Plate (1.000)*	18.0	0.092	131	21.3	0.118	120	20.8	0.708	375	31.2	1.667	118	28.3	0.181	104	12.0	0.050	160
-H112	Plate (2.000)*	16.8	0.083	135	19.9	0.106	125	19.4	0.647	406	27.1	1.384	109	26.4	0.163	108	10.6	0.041	171
-H112	Plate (3.000)*	16.8	0.083	135	19.9	0.106	125	19.4	0.647	406	27.1	1.384	109	26.4	0.163	108	10.6	0.041	171
-H32	(Sheet & Plate)	30.2	0.199	101	36.1	0.261	92	34.6	1.396	235	51.9	3.285	84	48.1	0.401	80	22.5	0.128	117
-H34	(Drawn Tube)	37.7	0.278	90	45.4	0.367	82	43.0	1.867	192	64.6	4.394	73	60.5	0.565	71	28.8	0.185	104
5454-H111	Extrusions (All)	18.0	0.092	131	21.3	0.118	120	20.8	0.708	375	31.2	1.667	118	28.3	0.181	104	14.9	0.069	144
-H112	Extrusions	14.5	0.066	146	17.0	0.084	135	16.7	0.530	468	23.1	1.116	118	22.6	0.129	117	9.2	0.033	184
-H32	Sheet & Plate	27.7	0.175	105	33.1	0.229	97	31.8	1.248	254	47.7	2.937	89	44.1	0.351	84	21.0	0.115	121
-H34	Sheet & Plate	31.4	0.212	99	37.7	0.278	91	36.0	1.472	226	54.0	3.463	82	50.1	0.426	78	24.1	0.142	113
5456-H111	Extrusions (All)	25.3	0.152	110	30.1	0.198	101	29.0	1.105	279	43.6	2.600	94	40.0	0.304	88	21.0	0.115	121
-H112	Extrusions	22.8	0.131	116	27.1	0.170	107	26.3	0.967	301	37.4	2.119	93	36.1	0.260	92	14.9	0.069	144
-H321	Sheet & Plate	31.4	0.212	99	37.7	0.278	91	36.0	1.472	226	54.0	3.463	82	50.1	0.426	78	27.2	0.170	107
-H321	Plate (1.500)*	29.0	0.187	103	34.6	0.245	94	33.2	1.321	244	49.8	3.110	86	46.1	0.376	82	25.6	0.156	110
-H321	Plate (3.000)*	29.0	0.187	103	34.6	0.245	94	33.2	1.321	244	49.8	3.110	86	46.1	0.376	82	24.1	0.142	113
-H323	Sheet	40.3	0.307	88	48.5	0.406	80	45.9	2.033	180	68.8	4.784	70	64.7	0.624	69	30.3	0.201	101
-H343	Sheet	46.7	0.383	81	56.4	0.509	74	53.0	2.464	157	79.5	5.799	63	75.3	0.784	64	35.2	0.250	94
6061-T6,T651	Sheet & Plate	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6,T6510**	Extrusions	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6,T651	Rolled Rod	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6	Drawn Tube	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6	Pipe (0.999)*	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6	Pipe	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
6063-T5	Extrusions (0.500)*	17.3	0.072	99	19.5	0.086	93	19.2	0.529	275	28.8	1.513	95	28.3	0.183	103	11.0	0.036	124
-T5	Extrusions	16.2	0.065	102	18.2	0.078	96	18.0	0.484	289	26.9	1.384	99	26.4	0.165	107	10.4	0.033	128
-T6	Extrusions	27.6	0.145	78	31.4	0.175	73	30.5	0.978	188	45.7	2.800	70	46.1	0.381	81	17.6	0.074	98
	Pipe																		

* Maximum thickness indicated in parentheses. See Table 3.3.1a for corresponding thickness range.

** Values also apply to -T6511 temper.

TABLE 3.3.2
MINIMUM MECHANICAL PROPERTIES FOR
WELDED ALUMINUM ALLOYS†

(Gas Tungsten Arc or Gas Metal Arc Welding With No Postweld Heat Treatment)

Alloy And Temper	Product And Thickness Range in.	TENSION		COM- PRES- SION $F_{cyw}^{\ddagger}$ ksi	SHEAR		BEARING	
		$F_{tuw}^{\dagger}$ ksi	$F_{tyw}^{\dagger}$ ksi		F_{suw} ksi	F_{syw} ksi	F_{buw} ksi	F_{byw} ksi
1100-H12,H14	All	11	4.5	4.5	8	2.5	23	8
3003-H12,H14,H16,H18	All	14	7	7	10	4	30	12
Alclad 3003-H12,H14,H16,H18	All	13	6	6	10	3.5	30	11
3004-H32,H34,H36	All	22	11	11	14	6.5	46	20
Alclad 3004-H32,H34,H14,H16	All	21	11	11	13	6.5	44	19
3005-H25	Sheet 0.013-0.050	17	9	9	12	5	36	15
5005-H12,H14,H32,H34	All	14	7	7	9	4	28	10
5050-H32,H34	All	18	8	8	12	4.5	36	12
5052-H32,H34	All	25	13	13	16	7.5	50	19
5083-H111	Extrusions	39	21	20	23	12	78	32
-H321	Sheet & Plate 0.188-1.500	40	24	24	24	14	80	36
-H321	Plate 1.501-3.000	39	23	23	24	13	78	34
-H323,H343	Sheet	40	24	24	24	14	80	36
5086-H111	Extrusions	35	18	17	21	10	70	28
-H112	Plate 0.250-0.499	35	17	17	21	9.5	70	28
-H112	Plate 0.500-1.000	35	16	16	21	9	70	28
-H112	Plate 1.001-2.000	35	14	14	21	8	70	28
-H32,H34	Sheet & Plate	35	19	19	21	11	70	28
5154-H38	Sheet	30	15	15	19	8.5	60	23
5454-H111	Extrusions	31	16	15	19	9.5	62	24
-H112	Extrusions	31	12	12	19	7	62	24
-H32,H34	Sheet & Plate	31	16	16	19	9.5	62	24
5456-H111	Extrusions	41	24	22	24	14	82	38
-H112	Extrusions	41	19	19	24	11	82	38
-H321	Sheet & Plate 0.188-1.500	42	26	24	25	15	84	38
-H321	Plate 1.501-3.000	41	24	23	25	14	82	36
-H323,H343	Sheet	42	26	26	25	15	84	38
6061-T6,T651*	All	24	20	20	15	12	50	30
-T6,T651**	Over 0.375	24	15	15	15	9	50	30
6063-T5,T6	All	17	11	11	11	6.5	34	22

†Filler wires used are those recommended in Table 7.1.3.1. Values of F_{tuw} are ASME weld qualification test values.

‡0.2 percent offset in 10 in. gage length across a butt weld.

*Values when welded with 5183, 5356, or 5556 alloy filler wire. Values also apply to -T6510, -T6511 extrusion tempers.

**Values when welded with 4043, 5154, 5254, or 5554 alloy filler wire. Values also apply to -T6510, -T6511 extrusion tempers.

TABLE 3.3.3
FACTORS OF SAFETY FOR USE WITH ALUMINUM
ALLOWABLE STRESS SPECIFICATIONS

	Building And Similar Type Structures	Bridge And Similar Type Structures
<i>Tension Members</i>		
F.S. on tensile strength, n_u	1.95	2.20
F.S. on yield strength, n_y	1.65	1.85
<i>Columns</i>		
F.S. on buckling strength, n_u	1.95	2.20
F.S. on crippling strength of thin sections, n_u	1.95	2.20
F.S. on yield strength for short columns, n_y	1.65	1.85
<i>Beams</i>		
F.S. on tensile strength, n_u	1.95	2.20
F.S. on tensile yield strength, n_y	1.65	1.85
F.S. on compressive yield strength for short beams, n_y	1.65	1.85
F.S. on buckling strength, n_y	1.65	1.85
F.S. on crippling strength of thin sections, n_y	1.65	1.85
F.S. on shear buckling of webs, n_a	1.20	1.35
<i>Connections</i>		
F.S. on bearing strength.....	$1.2 \times 1.95 = 2.34$	2.64
F.S. on bearing yield strength, n_y	1.65	1.85
F.S. on shear strength of rivets and bolts.....	$1.2 \times 1.95 = 2.34$	2.64
F.S. on shear strength of fillet welds.....	$1.2 \times 1.95 = 2.34$	2.64
F.S. on tensile strength of butt welds, n_u	1.95	2.20
F.S. on tensile yield strength of butt welds, n_y	1.65	1.85

TABLE 3.3.4a
FORMULAS FOR BUCKLING CONSTANTS

For All Products Whose Temper Designation Begins With -O, -H, -T1, -T2, -T3, or -T4

Type of Member and Stress	Intercept, ksi	Slope, ksi	Intersection
Compression in Columns and Beam Flanges	$B_c = F_{cy} \left[1 + \left(\frac{F_{cy}}{1000} \right)^{1/2} \right]$	$D_c = \frac{B_c (6B_c)^{1/2}}{20(E)}$	$C_c = \frac{2B_c}{3D_c}$
Compression in Flat Plates	$B_p = F_{cy} \left[1 + \frac{(F_{cy})^{1/3}}{7.6} \right]$	$D_p = \frac{B_p (6B_p)^{1/2}}{20(E)}$	$C_p = \frac{2B_p}{3D_p}$
Compression in Round Tubes Under Axial End Load	$B_t = F_{cy} \left[1 + \frac{(F_{cy})^{1/5}}{5.8} \right]$	$D_t = \frac{B_t (B_t)^{1/3}}{3.7(E)}$	$C_t \quad *$
Compressive Bending Stress in Solid Rec- tangular Bars	$B_b = 1.3F_{cy} \left[1 + \frac{(F_{cy})^{1/3}}{7} \right]$	$D_b = \frac{B_b (6B_b)^{1/2}}{20(E)}$	$C_b = \frac{2B_b}{3D_b}$
Compressive Bending Stress in Round Tubes	$B_{tb} = 1.5F_y \left[1 + \frac{(F_y)^{1/5}}{5.8} \right]$	$D_{tb} = \frac{B_{tb} (B_{tb})^{1/3}}{2.7(E)}$	$C_{tb} = \left(\frac{B_{tb} - B_t}{D_{tb} - D_t} \right)^2$
Shear Stress in Flat Plates	$B_s = F_{sy} \left[1 + \frac{(F_{sy})^{1/3}}{6.2} \right]$	$D_s = \frac{B_s (6B_s)^{1/2}}{20(E)}$	$C_s = \frac{2B_s}{3D_s}$
Crippling of Flat Plates in Compression or Bending	$k_1 = 0.50$	$k_2 = 2.04$	

* C_t can be found from a plot of the curves of allowable stress based on elastic and inelastic buckling or by a trial and error solution.

formulas for constants

TABLE 3.3.4b
FORMULAS FOR BUCKLING CONSTANTS

For Products Whose Temper Designation Begins With -T5, -T6, -T7, -T8, or -T9

Type of Member and Stress	Intercept, ksi	Slope, ksi	Intersection
Compression in Columns and Beam Flanges	$B_c = F_{cy} \left[1 + \left(\frac{F_{cy}}{2250} \right)^{1/2} \right]$	$D_c = \frac{B_c (B_c)^{1/2}}{10 (E)^{1/2}}$	$C_c = 0.41 \frac{B_c}{D_c}$
Compression in Flat Plates	$B_p = F_{cy} \left[1 + \left(\frac{F_{cy}}{11.4} \right)^{1/3} \right]$	$D_p = \frac{B_p (B_p)^{1/2}}{10 (E)^{1/2}}$	$C_p = 0.41 \frac{B_p}{D_p}$
Compression in Round Tubes Under Axial End Load	$B_t = F_{cy} \left[1 + \left(\frac{F_{cy}}{8.7} \right)^{1/5} \right]$	$D_t = \frac{B_t (B_t)^{1/3}}{4.5 (E)^{1/3}}$	C_t *
Compressive Bending Stress in Solid Rectangular Bars	$B_b = 1.3 F_{cy} \left[1 + \left(\frac{F_{cy}}{7} \right)^{1/3} \right]$	$D_b = \frac{B_b (6 B_b)^{1/2}}{20 (E)^{1/2}}$	$C_b = \frac{2 B_b}{3 D_b}$
Compressive Bending Stress in Round Tubes	$B_{tb} = 1.5 F_y \left[1 + \left(\frac{F_y}{8.7} \right)^{1/5} \right]$	$D_{tb} = \frac{B_{tb} (B_{tb})^{1/3}}{2.7 (E)^{1/3}}$	$C_{tb} = \left(\frac{B_{tb} - B_t}{D_{tb} - D_t} \right)^2$
Shear Stress in Flat Plates	$B_s = F_{sy} \left[1 + \left(\frac{F_{sy}}{9.3} \right)^{1/3} \right]$	$D_s = \frac{B_s (B_s)^{1/2}}{10 (E)^{1/2}}$	$C_s = 0.41 \frac{B_s}{D_s}$
Crippling of Flat Plates in Compression	$k_1 = 0.35$	$k_2 = 2.27$	
Crippling of Flat Plates in Bending	$k_1 = 0.50$	$k_2 = 2.04$	

* C_t can be found from a plot of the curves of allowable stress based on elastic and inelastic buckling or by a trial and error solution.

TABLE 3.3.5
VALUES OF COEFFICIENTS k_t and k_c *

Alloy and Temper	Non-welded or Regions Farther Than 1.0 in. From a Weld		Regions Within 1.0 in. of a Weld	
	k_t	k_c	k_t	k_c †
2014-T6, -T651‡	1.25	1.12	—	—
Alclad 2014-T6, -T651	1.25	1.12	—	—
6061-T6, -T651‡	1.0	1.12	1.0	1.0
6063-T5, -T6, -T83	1.0	1.12	1.0	1.0
All Others Listed in Table 3.3.1	1.0	1.10	1.0	1.0

* These coefficients are used in the formulas in Table 3.3.6.

† If the weld yield strength exceeds 0.9 of the parent metal yield strength, the allowable compressive stress within 1.0 in. of a weld should be taken equal to the allowable stress for non-welded material.

‡ Values also apply to -T6510, -T6511 extrusion tempers.

Methods of Rounding Off Numbers in Tables 3.3.6 to 3.3.27

The allowable stresses in Specifications 1-6 and for slenderness $\leq S_1$ in Specifications 7-21 are obtained by rounding off stresses below 5 ksi to the nearest 0.1 ksi; stresses between 5 and 15 ksi to the nearest 0.5 ksi; and stresses over 15 ksi to the nearest 1.0 ksi. To obtain allowable stresses for slenderness between S_1 and S_2 , the constant is rounded off to the nearest 0.1 ksi. The coefficient of the slenderness ratio is rounded off according to the rule: for numbers between 2×10^n and $2 \times 10^{n+1}$, round off to nearest 0.1×10^n , where n is any positive or negative integer. This same rule is applied to the coefficients in the expressions for allowable stresses for slenderness $\geq S_2$.

Slenderness limits S_1 and S_2 are based on the rounded off expressions for allowable stress obtained as described above. Values of S_1 and S_2 between 10 and 250 are rounded off to the nearest 1.0. Smaller values are rounded off to the nearest 0.1, and larger values to the nearest 10. If S_2 is not more than 5 per cent larger than S_1 , the allowable stress for slenderness between S_1 and S_2 is taken to be the same as the allowable stress for slenderness $\leq S_1$. In this case there is no value for S_1 and the value of S_2 is recalculated by equating the allowable stress for slenderness less than S_2 to the allowable stress for slenderness $\geq S_2$, using rounded off values.

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.6 General Formulas for Determining Allowable Stresses		
TENSION, axial, net section		Any tension member:	1	F_{ty}/n_y or $F_{tu}/(k_t n_u)$				
TENSION IN BEAMS, extreme fiber, net section		Rectangular tubes, structural shapes bent about strong axis	2	F_{ty}/n_y or $F_{tu}/(k_t n_u)$				
		Round or oval tubes	3	$1.17F_{ty}/n_y$ or $1.24F_{tu}/(k_t n_u)$				
		Rectangular bars, plates, shapes bent about weak axis	4	$1.30F_{ty}/n_y$ or $1.42F_{tu}/(k_t n_u)$				
BEARING		On rivets and bolts	5	F_{by}/n_y or $F_{bu}/(1.2n_u)$				
		On flat surfaces and pins	6	$F_{by}/(1.5n_y)$ or $F_{bu}/(1.8n_u)$				
				Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section		All columns	7	$\frac{F_{cy}}{k_c n_y}$	$\frac{L}{r} = \frac{B_c - \frac{n_u F_{cy}}{k_c n_y}}{D_c}$	$\frac{1}{n_u} \left(B_c - D_c \frac{L}{r} \right)$	$\frac{L}{r} = C_c$	$\frac{\pi^2 E}{n_u (L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section		Outstanding flanges and legs	8	$\frac{F_{cy}}{k_c n_y}$	$\frac{b}{t} = \frac{B_p - \frac{n_u F_{cy}}{k_c n_y}}{5.1 D_p}$	$\frac{1}{n_u} \left(B_p - 5.1 D_p \frac{b}{t} \right)$	$\frac{b}{t} = \frac{C_p}{5.1}$	$\frac{\pi^2 E}{n_u (5.1b/t)^2}$
		Flat plates with both edges supported	9	$\frac{F_{cy}}{k_c n_y}$	$\frac{b}{t} = \frac{B_p - \frac{n_u F_{cy}}{k_c n_y}}{1.6 D_p}$	$\frac{1}{n_u} \left(B_p - 1.6 D_p \frac{b}{t} \right)$	$\frac{b}{t} = \frac{k_1 B_p}{1.6 D_p}$	$\frac{k_2 \sqrt{B_p E}}{n_u (1.6b/t)}$
		Curved plates supported on both edges, walls of round or oval tubes	10	$\frac{F_{cy}}{k_c n_y}$	$\frac{R}{t} = \left(\frac{B_t - \frac{n_u F_{cy}}{k_c n_y}}{D_t} \right)^2$	$\frac{1}{n_u} \left(B_t - D_t \sqrt{\frac{R}{t}} \right)$	$\frac{R}{t} = C_t$	$\frac{\pi^2 E}{16 n_u \left(\frac{R}{t} \right) \left(1 + \frac{\sqrt{R/t}}{35} \right)^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section		Single web beams bent about strong axis	11	$\frac{F_{cy}}{n_y}$	$\frac{L_b}{r_y} = \frac{1.2(B_c - F_{cy})}{D_c}$	$\frac{1}{n_y} \left(B_c - \frac{D_c L_b}{1.2 r_y} \right)$	$\frac{L_b}{r_y} = 1.2 C_c$	$\frac{\pi^2 E}{n_y (L_b/1.2 r_y)^2}$
		Round or oval tubes	12	$\frac{1.17 F_{cy}}{n_y}$	$\frac{R_b}{t} = \left(\frac{B_{tb} - 1.17 F_{cy}}{D_{tb}} \right)^2$	$\frac{1}{n_y} \left(B_{tb} - D_{tb} \sqrt{\frac{R_b}{t}} \right)$	$\frac{R_b}{t} = \left(\frac{n_u B_{tb} - B_t}{\frac{n_u D_{tb}}{n_y} - D_t} \right)^2$	Same as Specification 10 (See Par. 3.4.12)
		Solid rectangular beams	13	$\frac{1.3 F_{cy}}{n_y}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = \frac{B_b - 1.3 F_{cy}}{2.3 D_b}$	$\frac{1}{n_y} \left(B_b - 2.3 D_b \frac{d}{t} \sqrt{\frac{L_b}{d}} \right)$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = \frac{C_b}{2.3}$	$\frac{\pi^2 E}{5.29 n_y (d/t)^2 (L_b/d)}$
		Rectangular tubes and box sections	14	$\frac{F_{cy}}{n_y}$	$\frac{L_b S_c}{I_y} = \left(\frac{B_c - F_{cy}}{1.6 D_c} \right)^2$	$\frac{1}{n_y} \left(B_c - 1.6 D_c \sqrt{\frac{L_b S_c}{I_y}} \right)$	$\frac{L_b S_c}{I_y} = \left(\frac{C_c}{1.6} \right)^2$	$\frac{\pi^2 E}{2.56 n_y (L_b S_c / I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section		Outstanding flanges	15	$\frac{F_{cy}}{n_y}$	$\frac{b}{t} = \frac{B_p - F_{cy}}{5.1 D_p}$	$\frac{1}{n_y} \left(B_p - 5.1 D_p \frac{b}{t} \right)$	$\frac{b}{t} = \frac{k_1 B_p}{5.1 D_p}$	$\frac{k_2 \sqrt{B_p E}}{n_y (5.1b/t)}$
		Flat plates with both edges supported	16	$\frac{F_{cy}}{n_y}$	$\frac{b}{t} = \frac{B_p - F_{cy}}{1.6 D_p}$	$\frac{1}{n_y} \left(B_p - 1.6 D_p \frac{b}{t} \right)$	$\frac{b}{t} = \frac{k_1 B_p}{1.6 D_p}$	$\frac{k_2 \sqrt{B_p E}}{n_y (1.6b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section		Flat plates with compression edge free, tension edge supported	17	$\frac{1.3 F_{cy}}{n_y}$	$\frac{b}{t} = \frac{B_b - 1.3 F_{cy}}{3.5 D_b}$	$\frac{1}{n_y} \left(B_b - 3.5 D_b \frac{b}{t} \right)$	$\frac{b}{t} = \frac{C_b}{3.5}$	$\frac{\pi^2 E}{n_y (3.5b/t)^2}$
		Flat plates with both edges supported	18	$\frac{1.3 F_{cy}}{n_y}$	$\frac{h}{t} = \frac{B_b - 1.3 F_{cy}}{0.67 D_b}$	$\frac{1}{n_y} \left(B_b - 0.67 D_b \frac{h}{t} \right)$	$\frac{h}{t} = \frac{k_1 B_b}{0.67 D_b}$	$\frac{k_2 \sqrt{B_b E}}{n_y (0.67h/t)}$
		Flat plates with horizontal stiffener, both edges supported	19	$\frac{1.3 F_{cy}}{n_y}$	$\frac{h}{t} = \frac{B_b - 1.3 F_{cy}}{0.29 D_b}$	$\frac{1}{n_y} \left(B_b - 0.29 D_b \frac{h}{t} \right)$	$\frac{h}{t} = \frac{k_1 B_b}{0.29 D_b}$	$\frac{k_2 \sqrt{B_b E}}{n_y (0.29h/t)}$
SHEAR IN WEBS, gross section		Unstiffened flat webs	20	$\frac{F_{sy}}{n_y}$	$\frac{h}{t} = \frac{B_s - F_{sy}}{1.25 D_s}$	$\frac{1}{n_y} \left(B_s - 1.25 D_s \frac{h}{t} \right)$	$\frac{h}{t} = \frac{C_s}{1.25}$	$\frac{\pi^2 E}{n_y (1.25h/t)^2}$
		Stiffened flat webs $a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$	21	$\frac{F_{sy}}{n_y}$	$\frac{a_e}{t} = \frac{B_s - \frac{n_u F_{sy}}{n_y}}{1.25 D_s}$	$\frac{1}{n_u} \left(B_s - 1.25 D_s \frac{a_e}{t} \right)$	$\frac{a_e}{t} = \frac{C_s}{1.25}$	$\frac{\pi^2 E}{n_u (1.25 a_e/t)^2}$

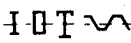
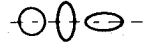
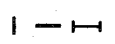
Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.7 Allowable Stresses for BUILDING and Similar Type Structures 1100 – H14 Sheet and Plate Rolled Rod and Bar Drawn Tube		
TENSION, axial, net section	Any tension member:	1	8	2.7				
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	8	2.7				
	Round or oval tubes	3	10	3.2				
	Rectangular bars, plates, shapes bent about weak axis	4	11	3.5				
BEARING	On rivets and bolts	5	12.5	4.8				
	On flat surfaces and pins	6	8.5	3.2				

			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	7	$\frac{L}{r} = 12$	$7.4 - 0.034 \frac{L}{r}$	$\frac{L}{r} = 144$	$\frac{51,000}{(L/r)^2}$
			2.7	---	2.7	$\frac{L}{r} = 137$	$\frac{51,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	7	$\frac{b}{t} = 7.7$	$8.7 - 0.22 \frac{b}{t}$	$\frac{b}{t} = 26$	$\frac{1,970}{(b/t)^2}$
	2.7		---	2.7	$\frac{b}{t} = 27$	$\frac{1,970}{(b/t)^2}$	
	Flat plates with both edges supported	9	7	$\frac{b}{t} = 24$	$8.7 - 0.071 \frac{b}{t}$	$\frac{b}{t} = 62$	$\frac{270}{(b/t)}$
	2.7		---	2.7	$\frac{b}{t} = 100$	$\frac{270}{(b/t)}$	
	Curved plates supported on both edges, walls of round or oval tubes	10	7	$\frac{R}{t} = 35$	$8.6 - 0.27 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 460$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
	2.7		$\frac{R}{t} = 2.5$	$2.8 - 0.063 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 1160$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$	
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	8	$\frac{L_b}{r_y} = 24$	$8.8 - 0.034 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 173$	$\frac{87,000}{(L_b/r_y)^2}$
	2.7		---	2.7	$\frac{L_b}{r_y} = 180$	$\frac{87,000}{(L_b/r_y)^2}$	
	Round or oval tubes	12	9	$\frac{R_b}{t} = 67$	$15.2 - 0.76 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 181$	Same as Specification No. 10
	3.2		$\frac{R_b}{t} = 106$	$5.0 - 0.175 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 390$	Same as Specification No. 10	
	Solid rectangular beams	13	10	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 20$	$13.7 - 0.183 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 50$	$\frac{11,400}{(d/t)^2 (L_b/d)}$
	3.5		---	3.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 57$	$\frac{11,400}{(d/t)^2 (L_b/d)}$	
	Rectangular tubes and box sections	14	8	$\frac{L_b S_c}{I_y} = 151$	$8.8 - 0.065 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 8100$	$\frac{24,000}{(L_b S_c / I_y)}$
	2.7		---	2.7	$\frac{L_b S_c}{I_y} = 8890$	$\frac{24,000}{(L_b S_c / I_y)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	8	$\frac{b}{t} = 8.5$	$10.3 - 0.27 \frac{b}{t}$	$\frac{b}{t} = 19$	$\frac{100}{(b/t)}$
	2.7		---	2.7	$\frac{b}{t} = 37$	$\frac{100}{(b/t)}$	
	Flat plates with both edges supported	16	8	$\frac{b}{t} = 28$	$10.3 - 0.083 \frac{b}{t}$	$\frac{b}{t} = 62$	$\frac{320}{(b/t)}$
	2.7		---	2.7	$\frac{b}{t} = 119$	$\frac{320}{(b/t)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	10	$\frac{b}{t} = 13$	$13.7 - 0.28 \frac{b}{t}$	$\frac{b}{t} = 33$	$\frac{4,900}{(b/t)^2}$
	3.5		---	3.5	$\frac{b}{t} = 37$	$\frac{4,900}{(b/t)^2}$	
	Flat plates with both edges supported	18	10	$\frac{h}{t} = 70$	$13.7 - 0.053 \frac{h}{t}$	$\frac{h}{t} = 129$	$\frac{880}{(h/t)}$
3.5	---		3.5	$\frac{h}{t} = 250$	$\frac{880}{(h/t)}$		
	Flat plates with horizontal stiffener, both edges supported	19	10	$\frac{h}{t} = 161$	$13.7 - 0.023 \frac{h}{t}$	$\frac{h}{t} = 300$	$\frac{2,000}{(h/t)}$
	3.5		---	3.5	$\frac{h}{t} = 570$	$\frac{2,000}{(h/t)}$	
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	4.8	$\frac{h}{t} = 50$	$6.4 - 0.032 \frac{h}{t}$	$\frac{h}{t} = 134$	$\frac{39,000}{(h/t)^2}$
	1.5		---	1.5	$\frac{h}{t} = 161$	$\frac{39,000}{(h/t)^2}$	
	Stiffened flat webs	21	4.8	$\frac{a_e}{t} = 91$	$8.8 - 0.044 \frac{a_e}{t}$	$\frac{a_e}{t} = 134$	$\frac{53,000}{(a_e/t)^2}$
	1.5		---	1.5	$\frac{a_e}{t} = 188$	$\frac{53,000}{(a_e/t)^2}$	

Table 3.3.7
Allowable Stresses for
BUILDING and Similar
Type Structures
1100—H14
Sheet and Plate
Rolled Rod and Bar
Drawn Tube

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.8* Allowable Stresses for BUILDING and Similar Type Structures 2014-T6, -T651 Sheet and Plate 2014-T6,-T6510,-T6511 Extrusions Alclad 2014-T6, -T651 Sheet and Plate			
TENSION, axial, net section	Any tension member:	1	25					
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	25					
	Round or oval tubes	3	31					
	Rectangular bars, plates, shapes bent about weak axis	4	35					
BEARING	On rivets and bolts	5	49					
	On flat surfaces and pins	6	32					
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$	
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	30	$\frac{L}{r} = 10$	$32.6-0.25\frac{L}{r}$	$\frac{L}{r} = 54$	$\frac{55,000}{(L/r)^2}$	
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	30	$\frac{b}{t} = 4.8$	$37.6-1.57\frac{b}{t}$	$\frac{b}{t} = 9.8$	$\frac{2,100}{(b/t)^2}$	
	Flat plates with both edges supported	9	30	$\frac{b}{t} = 16$	$37.6-0.49\frac{b}{t}$	$\frac{b}{t} = 27$	$\frac{650}{(b/t)}$	
	Curved plates supported on both edges, walls of round or oval tubes	10	30	$\frac{R}{t} = 14$	$35.4-1.46\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 100$	$\frac{3,400}{(R/t)(1+\sqrt{R/t}/35)^2}$	
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	33	$\frac{L_b}{r_y} = 22$	$38.5-0.25\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 65$	$\frac{94,000}{(L_b/r_y)^2}$	
	Round or oval tubes	12	39	$\frac{R_b}{t} = 21$	$60.4-4.7\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 60$	Same as Specification No. 10	
	Solid rectangular beams	13	43	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 13$	$66.8-1.96\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 23$	$\frac{12,300}{(d/t)^2(L_b/d)}$	
	Rectangular tubes and box sections	14	33	$\frac{L_b S_c}{I_y} = 137$	$38.5-0.47\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 1140$	$\frac{25,000}{(L_b S_c/I_y)^2}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	33	$\frac{b}{t} = 6.1$	$44.4-1.86\frac{b}{t}$	$\frac{b}{t} = 8.4$	$\frac{240}{(b/t)}$	
	Flat plates with both edges supported	16	33	$\frac{b}{t} = 20$	$44.4-0.58\frac{b}{t}$	$\frac{b}{t} = 27$	$\frac{770}{(b/t)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	43	$\frac{b}{t} = 8.2$	$66.8-2.9\frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{5,300}{(b/t)^2}$	
	Flat plates with both edges supported	18	43	---	43	$\frac{h}{t} = 47$	$\frac{2,000}{(h/t)}$	
	Flat plates with horizontal stiffener, both edges supported	19	43	---	43	$\frac{h}{t} = 109$	$\frac{4,700}{(h/t)}$	
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	19	$\frac{h}{t} = 32$	$25.2-0.194\frac{h}{t}$	$\frac{h}{t} = 53$	$\frac{42,000}{(h/t)^2}$	
	Stiffened flat webs $a_e = a_1/\sqrt{1+0.7(a_1/a_2)^2}$	21	19	---	19	$\frac{a_e}{t} = 55$	$\frac{57,000}{(a_e/t)^2}$	

* Alloy 2014 is generally not welded. Data in this table apply to nonwelded members.

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	10.5	4.2
TENSION IN BEAMS, extreme fiber, net section		Rectangular tubes, structural shapes bent about strong axis 	2	10.5	4.2
		Round or oval tubes 	3	12	5
		Rectangular bars, plates, shapes bent about weak axis 	4	13.5	5.5
BEARING		On rivets and bolts	5	15	7.5
		On flat surfaces and pins	6	10	4.8

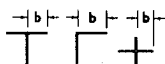
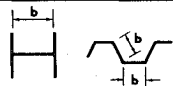
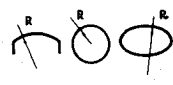
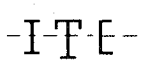
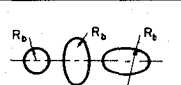
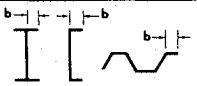
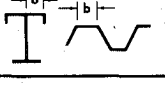
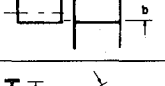
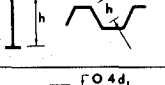
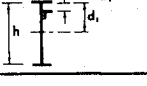
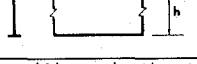
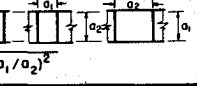
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi, Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi, Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		7.5	$\frac{L}{r} = 16$	$8.1 - 0.038 \frac{L}{r}$	$\frac{L}{r} = 138$	$\frac{51,000}{(L/r)^2}$
			4.2	$\frac{L}{r} = 103$	$8.1 - 0.038 \frac{L}{r}$	$\frac{L}{r} = 138$	$\frac{51,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs 		7.5	$\frac{b}{t} = 7.6$	$9.4 - 0.25 \frac{b}{t}$	$\frac{b}{t} = 25$	$\frac{1,970}{(b/t)^2}$
			4.2	$\frac{b}{t} = 21$	$9.4 - 0.25 \frac{b}{t}$	$\frac{b}{t} = 25$	$\frac{1,970}{(b/t)^2}$
	Flat plates with both edges supported 		7.5	$\frac{b}{t} = 24$	$9.4 - 0.079 \frac{b}{t}$	$\frac{b}{t} = 60$	$\frac{280}{(b/t)}$
			4.2	---	4.2	$\frac{b}{t} = 67$	$\frac{280}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes 		7.5	$\frac{R}{t} = 36$	$9.3 - 0.30 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 410$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
			4.2	$\frac{R}{t} = 6.7$	$4.5 - 0.116 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 810$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis 		8.5	$\frac{L_b}{r_y} = 26$	$9.5 - 0.038 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 166$	$\frac{87,000}{(L_b/r_y)^2}$
			4.2	$\frac{L_b}{r_y} = 139$	$9.5 - 0.038 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 166$	$\frac{87,000}{(L_b/r_y)^2}$
	Round or oval tubes 		10	$\frac{R_b}{t} = 57$	$16.4 - 0.85 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 167$	Same as Specification No. 10
			5	$\frac{R_b}{t} = 88$	$8.0 - 0.32 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 290$	Same as Specification No. 10
	Solid rectangular beams 		11	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 19$	$14.8 - 0.20 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 48$	$\frac{11,400}{(d/t)^2 (L_b/d)}$
			5.5	---	5.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 46$	$\frac{11,400}{(d/t)^2 (L_b/d)}$
	Rectangular tubes and box sections 		8.5	$\frac{L_b S_c}{I_y} = 188$	$9.5 - 0.073 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 7440$	$\frac{24,000}{(L_b S_c / I_y)}$
			4.2	$\frac{L_b S_c}{I_y} = 5270$	$9.5 - 0.073 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 7440$	$\frac{24,000}{(L_b S_c / I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges 		8.5	$\frac{b}{t} = 9.0$	$11.2 - 0.30 \frac{b}{t}$	$\frac{b}{t} = 19$	$\frac{105}{(b/t)}$
	Flat plates with both edges supported 		8.5	$\frac{b}{t} = 29$	$11.2 - 0.093 \frac{b}{t}$	$\frac{b}{t} = 60$	$\frac{330}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported 		11	$\frac{b}{t} = 12$	$14.8 - 0.31 \frac{b}{t}$	$\frac{b}{t} = 32$	$\frac{4,900}{(b/t)^2}$
			5.5	$\frac{b}{t} = 30$	$14.8 - 0.31 \frac{b}{t}$	$\frac{b}{t} = 32$	$\frac{4,900}{(b/t)^2}$
	Flat plates with both edges supported 		11	$\frac{h}{t} = 63$	$14.8 - 0.060 \frac{h}{t}$	$\frac{h}{t} = 124$	$\frac{920}{(h/t)}$
			5.5	---	5.5	$\frac{h}{t} = 167$	$\frac{920}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported 		11	$\frac{h}{t} = 146$	$14.8 - 0.026 \frac{h}{t}$	$\frac{h}{t} = 290$	$\frac{2,100}{(h/t)}$
			5.5	---	5.5	$\frac{h}{t} = 380$	$\frac{2,100}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs 		6	$\frac{h}{t} = 49$	$8.2 - 0.045 \frac{h}{t}$	$\frac{h}{t} = 119$	$\frac{39,000}{(h/t)^2}$
	Stiffened flat webs  $a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$		6	$\frac{a_e}{t} = 83$	$11.2 - 0.065 \frac{a_e}{t}$	$\frac{a_e}{t} = 119$	$\frac{53,000}{(a_e/t)^2}$
			2.4	---	2.4	$\frac{a_e}{t} = 149$	$\frac{53,000}{(a_e/t)^2}$

Table 3.3.9
Allowable Stresses for
BUILDING and Similar
Type Structures
3003—H14
Sheet and Plate
Rolled Rod and Bar,
Drawn Tube

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.10 Allowable Stresses for BUILDING and Similar Type Structures 3003—H16 Sheet Rolled Rod and Bar Drawn Tube			
TENSION, axial, net section	Any tension member:	1	12.5	4.2				
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	12.5	4.2				
	Round or oval tubes	3	15	5				
	Rectangular bars, plates, shapes bent about weak axis	4	17	5.5				
BEARING	On rivets and bolts	5	19	7.5				
	On flat surfaces and pins	6	12.5	4.8				
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi, Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi, Slenderness $\geq S_2$	
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	10	$\frac{L}{r} = 8.8$	$10.5 - 0.057 \frac{L}{r}$	$\frac{L}{r} = 121$	$\frac{51,000}{(L/r)^2}$	
			4.2	$\frac{L}{r} = 111$	$10.5 - 0.057 \frac{L}{r}$	$\frac{L}{r} = 121$	$\frac{51,000}{(L/r)^2}$	
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	10	$\frac{b}{t} = 6.3$	$12.4 - 0.38 \frac{b}{t}$	$\frac{b}{t} = 22$	$\frac{1,970}{(b/t)^2}$	
			4.2	---	4.2	$\frac{b}{t} = 22$	$\frac{1,970}{(b/t)^2}$	
	Flat plates with both edges supported	9	10	$\frac{b}{t} = 20$	$12.4 - 0.119 \frac{b}{t}$	$\frac{b}{t} = 52$	$\frac{320}{(b/t)}$	
			4.2	---	4.2	$\frac{b}{t} = 76$	$\frac{320}{(b/t)}$	
	Curved plates supported on both edges, walls of round or oval tubes	10	10	$\frac{R}{t} = 24$	$12.1 - 0.43 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 330$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$	
			4.2	$\frac{R}{t} = 6.7$	$4.5 - 0.116 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 810$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$	
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	11	$\frac{L_b}{r_y} = 25$	$12.4 - 0.057 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 145$	$\frac{87,000}{(L_b/r_y)^2}$	
			4.2	---	4.2	$\frac{L_b}{r_y} = 144$	$\frac{87,000}{(L_b/r_y)^2}$	
	Round or oval tubes	12	13	$\frac{R_b}{t} = 49$	$21.4 - 1.20 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 146$	Same as Specification No. 10.	
			5	$\frac{R_b}{t} = 88$	$8.0 - 0.32 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 290$	Same as Specification No. 10.	
	Solid rectangular beams	13	14	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 18$	$19.5 - 0.31 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 42$	$\frac{11,400}{(d/t)^2 (L_b/d)}$	
			5.5	---	5.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 46$	$\frac{11,400}{(d/t)^2 (L_b/d)}$	
	Rectangular tubes and box sections	14	11	$\frac{L_b S_c}{I_y} = 165$	$12.4 - 0.109 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 5720$	$\frac{24,000}{(L_b S_c/I_y)}$	
			4.2	---	4.2	$\frac{L_b S_c}{I_y} = 5710$	$\frac{24,000}{(L_b S_c/I_y)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	11	$\frac{b}{t} = 8.2$	$14.7 - 0.45 \frac{b}{t}$	$\frac{b}{t} = 16$	$\frac{120}{(b/t)}$	
	Flat plates with both edges supported	16	11	$\frac{b}{t} = 26$	$14.7 - 0.141 \frac{b}{t}$	$\frac{b}{t} = 52$	$\frac{380}{(b/t)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	14	$\frac{b}{t} = 12$	$19.5 - 0.47 \frac{b}{t}$	$\frac{b}{t} = 28$	$\frac{4,900}{(b/t)^2}$	
	Flat plates with both edges supported	18	14	$\frac{h}{t} = 61$	$19.5 - 0.090 \frac{h}{t}$	$\frac{h}{t} = 108$	$\frac{1,050}{(h/t)}$	
	Flat plates with horizontal stiffener, both edges supported	19	14	$\frac{h}{t} = 141$	$19.5 - 0.039 \frac{h}{t}$	$\frac{h}{t} = 250$	$\frac{2,400}{(h/t)}$	
	Unstiffened flat webs	20	7.5	$\frac{h}{t} = 39$	$9.9 - 0.061 \frac{h}{t}$	$\frac{h}{t} = 108$	$\frac{39,000}{(h/t)^2}$	
			2.4	---	2.4	$\frac{h}{t} = 127$	$\frac{39,000}{(h/t)^2}$	
SHEAR IN WEBS, gross section	Stiffened flat webs	21	7.5	$\frac{a_e}{t} = 74$	$13.7 - 0.084 \frac{a_e}{t}$	$\frac{a_e}{t} = 108$	$\frac{53,000}{(a_e/t)^2}$	
	$a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$		2.4	---	2.4	$\frac{a_e}{t} = 149$	$\frac{53,000}{(a_e/t)^2}$	

WHITE BARS

apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS

apply within 1.0 in. of a weld.

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.11 Allowable Stresses for BUILDING and Similar Type Structures Alclad 3004—H16 Sheet			
TENSION, axial, net section	Any tension member:	1	18	6.5				
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	18	6.5				
	Round or oval tubes	3	21	8				
	Rectangular bars, plates, shapes bent about weak axis	4	24	8.5				
BEARING	On rivets and bolts	5	27	11.5				
	On flat surfaces and pins	6	18	7.5				
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$	
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	14.5 6.5	$\frac{L}{r} = 9.6$ $\frac{L}{r} = 87$	$15.5 - 0.104 \frac{L}{r}$ $15.5 - 0.104 \frac{L}{r}$	$\frac{L}{r} = 100$ $\frac{L}{r} = 100$	$\frac{51,000}{(L/r)^2}$ $\frac{51,000}{(L/r)^2}$	
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	14.5 6.5	$\frac{b}{t} = 5.8$ $\frac{b}{t} = 17$	$18.5 - 0.69 \frac{b}{t}$ $18.5 - 0.69 \frac{b}{t}$	$\frac{b}{t} = 18$ $\frac{b}{t} = 18$	$\frac{1,970}{(b/t)^2}$ $\frac{1,970}{(b/t)^2}$	
	Flat plates with both edges supported	9	14.5 6.5	$\frac{b}{t} = 18$ ---	$18.5 - 0.22 \frac{b}{t}$ 6.5	$\frac{b}{t} = 43$ $\frac{b}{t} = 60$	$\frac{390}{(b/t)}$ $\frac{390}{(b/t)}$	
	Curved plates supported on both edges, walls of round or oval tubes	10	14.5 6.5	$\frac{R}{t} = 20$ $\frac{R}{t} = 10$	$17.7 - 0.72 \sqrt{\frac{R}{t}}$ $7.2 - 0.22 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 229$ $\frac{R}{t} = 510$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$ $\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$	
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	16 6.5	$\frac{L_b}{r_y} = 23$ ---	$18.3 - 0.102 \frac{L_b}{r_y}$ 6.5	$\frac{L_b}{r_y} = 120$ $\frac{L_b}{r_y} = 116$	$\frac{87,000}{(L_b/r_y)^2}$ $\frac{87,000}{(L_b/r_y)^2}$	
	Round or oval tubes	12	18 8	$\frac{R_b}{t} = 46$ $\frac{R_b}{t} = 62$	$31.5 - 2.0 \sqrt{\frac{R_b}{t}}$ $12.8 - 0.61 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 116$ $\frac{R_b}{t} = 206$	Same as Specification No. 10 Same as Specification No. 10	
	Solid rectangular beams	13	20 8.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 16$ ---	$29.2 - 0.57 \frac{d}{t} \sqrt{\frac{L_b}{d}}$ 8.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 34$ $\frac{d}{t} \sqrt{\frac{L_b}{d}} = 37$	$\frac{11,400}{(d/t)^2 (L_b/d)}$ $\frac{11,400}{(d/t)^2 (L_b/d)}$	
	Rectangular tubes and box sections	14	16 6.5	$\frac{L_b S_c}{I_y} = 138$ $\frac{L_b S_c}{I_y} = 3620$	$18.3 - 0.196 \sqrt{\frac{L_b S_c}{I_y}}$ $18.3 - 0.196 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3910$ $\frac{L_b S_c}{I_y} = 3910$	$\frac{24,000}{(L_b S_c/I_y)}$ $\frac{24,000}{(L_b S_c/I_y)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	16 6.5	$\frac{b}{t} = 7.2$ ---	$21.9 - 0.82 \frac{b}{t}$ 6.5	$\frac{b}{t} = 13$ $\frac{b}{t} = 22$	$\frac{146}{(b/t)}$ $\frac{146}{(b/t)}$	
	Flat plates with both edges supported	16	16 6.5	$\frac{b}{t} = 23$ ---	$21.9 - 0.26 \frac{b}{t}$ 6.5	$\frac{b}{t} = 43$ $\frac{b}{t} = 72$	$\frac{470}{(b/t)}$ $\frac{470}{(b/t)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	20 8.5	$\frac{b}{t} = 11$ ---	$29.2 - 0.86 \frac{b}{t}$ 8.5	$\frac{b}{t} = 23$ $\frac{b}{t} = 24$	$\frac{4,900}{(b/t)^2}$ $\frac{4,900}{(b/t)^2}$	
	Flat plates with both edges supported	18	20 8.5	$\frac{h}{t} = 56$ ---	$29.2 - 0.165 \frac{h}{t}$ 8.5	$\frac{h}{t} = 88$ $\frac{h}{t} = 152$	$\frac{1,290}{(h/t)}$ $\frac{1,290}{(h/t)}$	
	Flat plates with horizontal stiffener, both edges supported	19	20 8.5	$\frac{h}{t} = 128$ ---	$29.2 - 0.072 \frac{h}{t}$ 8.5	$\frac{h}{t} = 204$ $\frac{h}{t} = 350$	$\frac{3,000}{(h/t)}$ $\frac{3,000}{(h/t)}$	
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	10.5 3.9	$\frac{h}{t} = 38$ ---	$14.6 - 0.109 \frac{h}{t}$ 3.9	$\frac{h}{t} = 90$ $\frac{h}{t} = 100$	$\frac{39,000}{(h/t)^2}$ $\frac{39,000}{(h/t)^2}$	
	Stiffened flat webs $a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$	21	10.5 3.9	$\frac{a_e}{t} = 64$ ---	$20.1 - 0.150 \frac{a_e}{t}$ 3.9	$\frac{a_e}{t} = 90$ $\frac{a_e}{t} = 117$	$\frac{53,000}{(a_e/t)^2}$ $\frac{53,000}{(a_e/t)^2}$	

Table 3.3.11
Allowable Stresses for
BUILDING and Similar
Type Structures
Alclad 3004-H16
Sheet

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	14.5	6.5
		Rectangular tubes, structural shapes bent about strong axis	2	14.5	6.5
		Round or oval tubes	3	17	8
		Rectangular bars, plates, shapes bent about weak axis	4	19	8.5
TENSION IN BEAMS, extreme fiber, net section					
BEARING		On rivets and bolts	5	23	11.5
		On flat surfaces and pins	6	15	7.5

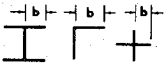
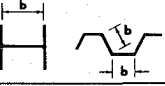
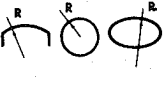
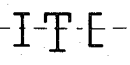
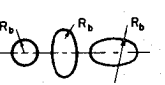
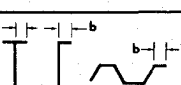
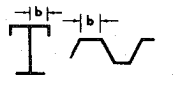
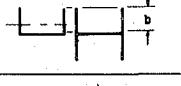
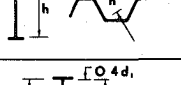
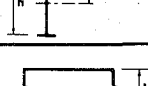
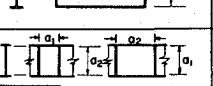
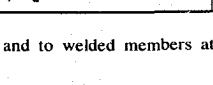
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		11.5	$\frac{L}{r} = 11$	$12.3 - 0.074 \frac{L}{r}$	$\frac{L}{r} = 112$	$\frac{51,000}{(L/r)^2}$
			6.5	$\frac{L}{r} = 78$	$12.3 - 0.074 \frac{L}{r}$	$\frac{L}{r} = 112$	$\frac{51,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs		11.5	$\frac{b}{t} = 6.5$	$14.7 - 0.49 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{1,970}{(L/r)^2}$
			6.5	$\frac{b}{t} = 17$	$14.7 - 0.49 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{1,970}{(L/r)^2}$
	Flat plates with both edges supported		11.5	$\frac{b}{t} = 21$	$14.7 - 0.153 \frac{b}{t}$	$\frac{b}{t} = 48$	$\frac{350}{(b/t)^2}$
			6.5	---	6.5	$\frac{b}{t} = 54$	$\frac{350}{(b/t)^2}$
	Curved plates supported on both edges, walls of round or oval tubes		11.5	$\frac{R}{t} = 25$	$14.2 - 0.54 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 280$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
			6.5	$\frac{R}{t} = 10$	$7.2 - 0.22 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 510$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis		12.5	$\frac{L_b}{r_y} = 27$	$14.5 - 0.073 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 134$	$\frac{87,000}{(L_b/r_y)^2}$
			6.5	$\frac{L_b}{r_y} = 110$	$14.5 - 0.073 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 134$	$\frac{87,000}{(L_b/r_y)^2}$
	Round or oval tubes		15	$\frac{R_b}{t} = 47$	$25.2 - 1.49 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 134$	Same as Specification No. 10
			8	$\frac{R_b}{t} = 62$	$12.8 - 0.61 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 206$	Same as Specification No. 10
	Solid rectangular beams		17	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 15$	$23.1 - 0.40 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 39$	$\frac{11,400}{(d/t)^2 (L_b/d)}$
			8.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 36$	$23.1 - 0.40 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 39$	$\frac{11,400}{(d/t)^2 (L_b/d)}$
	Rectangular tubes and box sections		12.5	$\frac{L_b S_c}{I_y} = 204$	$14.5 - 0.140 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 4900$	$\frac{24,000}{(L_b S_c / I_y)}$
			6.5	$\frac{L_b S_c}{I_y} = 3270$	$14.5 - 0.140 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 4900$	$\frac{24,000}{(L_b S_c / I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges		12.5	$\frac{b}{t} = 8.3$	$17.3 - 0.58 \frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{130}{(b/t)^2}$
			6.5	---	6.5	$\frac{b}{t} = 20$	$\frac{130}{(b/t)^2}$
	Flat plates with both edges supported		12.5	$\frac{b}{t} = 27$	$17.3 - 0.181 \frac{b}{t}$	$\frac{b}{t} = 48$	$\frac{420}{(b/t)^2}$
			6.5	---	6.5	$\frac{b}{t} = 65$	$\frac{420}{(b/t)^2}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported		17	$\frac{b}{t} = 10$	$23.1 - 0.61 \frac{b}{t}$	$\frac{b}{t} = 25$	$\frac{4,900}{(b/t)^2}$
			8.5	---	8.5	$\frac{b}{t} = 24$	$\frac{4,900}{(b/t)^2}$
	Flat plates with both edges supported		17	$\frac{h}{t} = 53$	$23.1 - 0.116 \frac{h}{t}$	$\frac{h}{t} = 99$	$\frac{1,140}{(h/t)^2}$
			8.5	---	8.5	$\frac{h}{t} = 134$	$\frac{1,140}{(h/t)^2}$
	Flat plates with horizontal stiffener, both edges supported		17	$\frac{h}{t} = 122$	$23.1 - 0.050 \frac{h}{t}$	$\frac{h}{t} = 230$	$\frac{2,600}{(h/t)^2}$
			8.5	---	8.5	$\frac{h}{t} = 310$	$\frac{2,600}{(h/t)^2}$
SHEAR IN WEBS, gross section	Unstiffened flat webs		8.5	$\frac{h}{t} = 42$	$11.8 - 0.079 \frac{h}{t}$	$\frac{h}{t} = 99$	$\frac{39,000}{(h/t)^2}$
			3.9	---	3.9	$\frac{h}{t} = 100$	$\frac{39,000}{(h/t)^2}$
	Stiffened flat webs		8.5	$\frac{a_e}{t} = 71$	$16.2 - 0.108 \frac{a_e}{t}$	$\frac{a_e}{t} = 99$	$\frac{53,000}{(a_e/t)^2}$
		$a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$	3.9	---	3.9	$\frac{a_e}{t} = 117$	$\frac{53,000}{(a_e/t)^2}$

Table 3.3.12
Allowable Stresses for
BUILDING and Similar
Type Structures
Alclad 3004-H34
Sheet

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	10.5	4.2
		Rectangular tubes, structural shapes bent about strong axis	2	10.5	4.2
		Round or oval tubes	3	12	5
		Rectangular bars, plates, shapes bent about weak axis	4	13.5	5.5
TENSION IN BEAMS, extreme fiber, net section		On rivets and bolts	5	15	6
		On flat surfaces and pins	6	10	4

			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		8.5	$\frac{L}{r} = 2.3$	$8.6 - 0.043 \frac{L}{r}$	$\frac{L}{r} = 133$	$\frac{51,000}{(\frac{L}{r})^2}$
			4.2	$\frac{L}{r} = 102$	$8.6 - 0.043 \frac{L}{r}$	$\frac{L}{r} = 133$	$\frac{51,000}{(\frac{L}{r})^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs		8.5	$\frac{b}{t} = 6.1$	$10.2 - 0.28 \frac{b}{t}$	$\frac{b}{t} = 24$	$\frac{1,970}{(\frac{b}{t})^2}$
			4.2	$\frac{b}{t} = 21$	$10.2 - 0.28 \frac{b}{t}$	$\frac{b}{t} = 24$	$\frac{1,970}{(\frac{b}{t})^2}$
	Flat plates with both edges supported		8.5	$\frac{b}{t} = 19$	$10.2 - 0.089 \frac{b}{t}$	$\frac{b}{t} = 58$	$\frac{290}{(\frac{b}{t})}$
			4.2	---	4.2	$\frac{b}{t} = 69$	$\frac{290}{(\frac{b}{t})}$
	Curved plates supported on both edges, walls of round or oval tubes		8.5	$\frac{R}{t} = 17$	$9.9 - 0.34 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 400$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
			4.2	$\frac{R}{t} = 6.7$	$4.5 - 0.116 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 810$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis		9	$\frac{L_b}{r_y} = 29$	$10.2 - 0.042 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 160$	$\frac{87,000}{(\frac{L_b}{r_y})^2}$
			4.2	$\frac{L_b}{r_y} = 143$	$10.2 - 0.042 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 160$	$\frac{87,000}{(\frac{L_b}{r_y})^2}$
	Round or oval tubes		10.5	$\frac{R_b}{t} = 60$	$17.7 - 0.93 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 175$	Same as Specification No. 10
			5	$\frac{R_b}{t} = 88$	$8.0 - 0.32 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 290$	Same as Specification No. 10
	Solid rectangular beams		12	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 17$	$16.0 - 0.23 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 47$	$\frac{11,400}{(\frac{d}{t})^2 (\frac{L_b}{d})}$
			5.5	---	5.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 46$	$\frac{11,400}{(\frac{d}{t})^2 (\frac{L_b}{d})}$
	Rectangular tubes and box sections		9	$\frac{L_b S_c}{I_y} = 219$	$10.2 - 0.081 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 6910$	$\frac{24,000}{(\frac{L_b S_c}{I_y})}$
			4.2	$\frac{L_b S_c}{I_y} = 5490$	$10.2 - 0.081 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 6910$	$\frac{24,000}{(\frac{L_b S_c}{I_y})}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges		9	$\frac{b}{t} = 9.4$	$12.1 - 0.33 \frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{109}{(\frac{b}{t})}$
			4.2	---	4.2	$\frac{b}{t} = 26$	$\frac{109}{(\frac{b}{t})}$
	Flat plates with both edges supported		9	$\frac{b}{t} = 30$	$12.1 - 0.105 \frac{b}{t}$	$\frac{b}{t} = 58$	$\frac{350}{(\frac{b}{t})}$
			4.2	---	4.2	$\frac{b}{t} = 83$	$\frac{350}{(\frac{b}{t})}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported		12	$\frac{b}{t} = 11$	$16.0 - 0.35 \frac{b}{t}$	$\frac{b}{t} = 31$	$\frac{4,900}{(\frac{b}{t})^2}$
			5.5	---	5.5	$\frac{b}{t} = 30$	$\frac{4,900}{(\frac{b}{t})^2}$
	Flat plates with both edges supported		12	$\frac{h}{t} = 60$	$16.0 - 0.067 \frac{h}{t}$	$\frac{h}{t} = 119$	$\frac{950}{(\frac{h}{t})}$
			5.5	---	5.5	$\frac{h}{t} = 173$	$\frac{950}{(\frac{h}{t})}$
	Flat plates with horizontal stiffener, both edges supported		12	$\frac{h}{t} = 138$	$16.0 - 0.029 \frac{h}{t}$	$\frac{h}{t} = 280$	$\frac{2,200}{(\frac{h}{t})}$
			5.5	---	5.5	$\frac{h}{t} = 400$	$\frac{2,200}{(\frac{h}{t})}$
SHEAR IN BEAMS, gross section	Unstiffened flat webs		6	$\frac{h}{t} = 49$	$8.2 - 0.045 \frac{h}{t}$	$\frac{h}{t} = 119$	$\frac{39,000}{(\frac{h}{t})^2}$
			2.4	---	2.4	$\frac{h}{t} = 127$	$\frac{39,000}{(\frac{h}{t})^2}$
	Stiffened flat webs		6	$\frac{a_e}{t} = 83$	$11.2 - 0.063 \frac{a_e}{t}$	$\frac{a_e}{t} = 119$	$\frac{53,000}{(\frac{a_e}{t})^2}$
		$a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$	2.4	---	2.4	$\frac{a_e}{t} = 149$	$\frac{53,000}{(\frac{a_e}{t})^2}$

Table 3.3.13
Allowable Stresses for
BUILDING and Similar
Type Structures
5005 – H14
Sheet and Plate

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	12	4.8
		Rectangular tubes, structural shapes bent about strong axis	2	12	4.8
		Round or oval tubes	3	14	5.5
		Rectangular bars, plates, shapes bent about weak axis	4	16	6.5
BEARING		On rivets and bolts	5	19	7.5
		On flat surfaces and pins	6	13	4.8

			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section		All columns	10	$\frac{L}{r} = 8.8$	$10.5 - 0.057 \frac{L}{r}$	$\frac{L}{r} = 121$	$\frac{51,000}{(L/r)^2}$
			4.8	$\frac{L}{r} = 100$	$10.5 - 0.057 \frac{L}{r}$	$\frac{L}{r} = 121$	$\frac{51,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section		Outstanding flanges and legs	10	$\frac{b}{t} = 6.3$	$12.4 - 0.38 \frac{b}{t}$	$\frac{b}{t} = 22$	$\frac{1,970}{(b/t)^2}$
			4.8	$\frac{b}{t} = 20$	$12.4 - 0.38 \frac{b}{t}$	$\frac{b}{t} = 22$	$\frac{1,970}{(b/t)^2}$
		Flat plates with both edges supported	10	$\frac{b}{t} = 20$	$12.4 - 0.119 \frac{b}{t}$	$\frac{b}{t} = 52$	$\frac{320}{(b/t)}$
			4.8	---	4.8	$\frac{b}{t} = 67$	$\frac{320}{(b/t)}$
		Curved plates supported on both edges, walls of round or oval tubes	10	$\frac{R}{t} = 24$	$12.1 - 0.43 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 330$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
			4.8	$\frac{R}{t} = 8.2$	$5.2 - 0.140 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 710$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section		Single web beams bent about strong axis	11	$\frac{L_b}{r_y} = 25$	$12.4 - 0.057 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 145$	$\frac{87,000}{(L_b/r_y)^2}$
			4.8	$\frac{L_b}{r_y} = 133$	$12.4 - 0.057 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 145$	$\frac{87,000}{(L_b/r_y)^2}$
		Round or oval tubes	12	$\frac{R_b}{t} = 49$	$21.4 - 1.20 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 146$	Same as Specification No. 10
			5.5	$\frac{R_b}{t} = 90$	$9.2 - 0.39 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 260$	Same as Specification No. 10
		Solid rectangular beams	13	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 18$	$19.5 - 0.31 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 42$	$\frac{11,400}{(d/t)^2 (L_b/d)}$
			6.5	---	6.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 42$	$\frac{11,400}{(d/t)^2 (L_b/d)}$
		Rectangular tubes and box sections	14	$\frac{L_b S_c}{I_y} = 165$	$12.4 - 0.109 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 5720$	$\frac{24,000}{(L_b S_c / I_y)}$
			4.8	$\frac{L_b S_c}{I_y} = 4860$	$12.4 - 0.109 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 5720$	$\frac{24,000}{(L_b S_c / I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section		Outstanding flanges	15	$\frac{b}{t} = 8.2$	$14.7 - 0.45 \frac{b}{t}$	$\frac{b}{t} = 16$	$\frac{120}{(b/t)}$
			4.8	---	4.8	$\frac{b}{t} = 25$	$\frac{120}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section		Flat plates with both edges supported	16	$\frac{b}{t} = 26$	$14.7 - 0.141 \frac{b}{t}$	$\frac{b}{t} = 52$	$\frac{380}{(b/t)}$
			4.8	---	4.8	$\frac{b}{t} = 79$	$\frac{380}{(b/t)}$
		Flat plates with compression edge free, tension edge supported	17	$\frac{b}{t} = 12$	$19.5 - 0.47 \frac{b}{t}$	$\frac{b}{t} = 28$	$\frac{4,900}{(b/t)^2}$
			6.5	---	6.5	$\frac{b}{t} = 27$	$\frac{4,900}{(b/t)^2}$
		Flat plates with both edges supported	18	$\frac{h}{t} = 61$	$19.5 - 0.090 \frac{h}{t}$	$\frac{h}{t} = 108$	$\frac{1,050}{(h/t)}$
			6.5	---	6.5	$\frac{h}{t} = 162$	$\frac{1,050}{(h/t)}$
SHEAR IN WEBS, gross section		Flat plates with horizontal stiffener, both edges supported	19	$\frac{h}{t} = 141$	$19.5 - 0.039 \frac{h}{t}$	$\frac{h}{t} = 250$	$\frac{2,400}{(h/t)}$
			6.5	---	6.5	$\frac{h}{t} = 370$	$\frac{2,400}{(h/t)}$
		Unstiffened flat webs	20	$\frac{h}{t} = 39$	$9.9 - 0.061 \frac{h}{t}$	$\frac{h}{t} = 108$	$\frac{39,000}{(h/t)^2}$
			2.7	---	2.7	$\frac{h}{t} = 120$	$\frac{39,000}{(h/t)^2}$
Stiffened flat webs			21	$\frac{a_e}{t} = 74$	$13.7 - 0.084 \frac{a_e}{t}$	$\frac{a_e}{t} = 108$	$\frac{53,000}{(a_e/t)^2}$
			2.7	---	2.7	$\frac{a_e}{t} = 140$	$\frac{53,000}{(a_e/t)^2}$

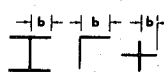
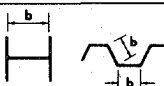
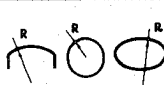
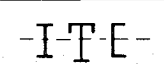
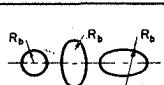
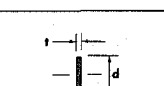
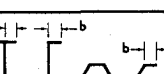
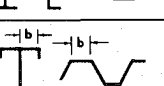
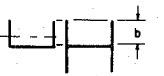
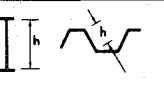
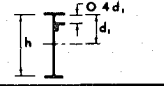
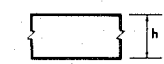
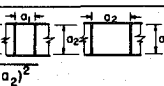
Table 3.3.14
Allowable Stresses for
BUILDING and Similar
Type Structures
5050 – H34
Sheet

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	16	8
TENSION IN BEAMS, extreme fiber, net section		Rectangular tubes, structural shapes bent about strong axis	2	16	8
		Round or oval tubes	3	18	9
		Rectangular bars, plates, shapes bent about weak axis	4	20	10
BEARING		On rivets and bolts	5	27	11.5
		On flat surfaces and pins	6	18	7.5

Table 3.3.15
Allowable Stresses for BUILDING and Similar Type Structures
5052 – H34
Sheet and Plate
Rolled Rod and Bar
Drawn Tube

			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		13	$\frac{L}{r} = 13$	$14.2 - 0.091 \frac{L}{r}$	$\frac{L}{r} = 104$	$\frac{52,000}{(\frac{L}{r})^2}$
			8	$\frac{L}{r} = 68$	$14.2 - 0.091 \frac{L}{r}$	$\frac{L}{r} = 104$	$\frac{52,000}{(\frac{L}{r})^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs		13	$\frac{b}{t} = 6.7$	$17.0 - 0.60 \frac{b}{t}$	$\frac{b}{t} = 19$	$\frac{1,980}{(\frac{b}{t})^2}$
	Flat plates with both edges supported		13	$\frac{b}{t} = 21$	$17.0 - 0.190 \frac{b}{t}$	$\frac{b}{t} = 45$	$\frac{380}{(\frac{b}{t})}$
			8	---	8	$\frac{b}{t} = 48$	$\frac{380}{(\frac{b}{t})}$
	Curved plates supported on both edges, walls of round or oval tubes		13	$\frac{R}{t} = 27$	$16.3 - 0.64 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 250$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
			8	$\frac{R}{t} = 4.9$	$8.6 - 0.27 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 460$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis		14.5	$\frac{L_b}{r_y} = 26$	$16.8 - 0.089 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 125$	$\frac{88,000}{(\frac{L_b}{r_y})^2}$
	Round or oval tubes		17	$\frac{R_b}{t} = 44$	$28.9 - 1.79 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 120$	Same as Specification No. 10
			9	$\frac{R_b}{t} = 67$	$15.2 - 0.76 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 181$	Same as Specification No. 10
	Solid rectangular beams		19	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 16$	$26.7 - 0.49 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 36$	$\frac{11,500}{(d/t)^2 (L_b/d)}$
			10	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 34$	$26.7 - 0.49 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 36$	$\frac{11,500}{(d/t)^2 (L_b/d)}$
	Rectangular tubes and box sections		14.5	$\frac{L_b S_c}{I_y} = 179$	$16.8 - 0.172 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 4220$	$\frac{24,000}{(L_b S_c / I_y)}$
			8	$\frac{L_b S_c}{I_y} = 2620$	$16.8 - 0.172 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 4220$	$\frac{24,000}{(L_b S_c / I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges		14.5	$\frac{b}{t} = 7.9$	$20.1 - 0.71 \frac{b}{t}$	$\frac{b}{t} = 14$	$\frac{141}{(\frac{b}{t})}$
	Flat plates with both edges supported		14.5	$\frac{b}{t} = 25$	$20.1 - 0.22 \frac{b}{t}$	$\frac{b}{t} = 45$	$\frac{450}{(\frac{b}{t})}$
			8	---	8	$\frac{b}{t} = 56$	$\frac{450}{(\frac{b}{t})}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported		19	$\frac{b}{t} = 10$	$26.7 - 0.75 \frac{b}{t}$	$\frac{b}{t} = 24$	$\frac{5,000}{(\frac{b}{t})^2}$
	Flat plates with both edges supported		19	$\frac{h}{t} = 53$	$26.7 - 0.144 \frac{h}{t}$	$\frac{h}{t} = 93$	$\frac{1,240}{(\frac{h}{t})}$
			10	---	10	$\frac{h}{t} = 124$	$\frac{1,240}{(\frac{h}{t})}$
	Flat plates with horizontal stiffener, both edges supported		19	$\frac{h}{t} = 124$	$26.7 - 0.062 \frac{h}{t}$	$\frac{h}{t} = 214$	$\frac{2,900}{(\frac{h}{t})}$
			10	---	10	$\frac{h}{t} = 290$	$\frac{2,900}{(\frac{h}{t})}$
SHEAR IN WEBS, gross section	Unstiffened flat webs		9	$\frac{h}{t} = 42$	$12.7 - 0.088 \frac{h}{t}$	$\frac{h}{t} = 96$	$\frac{39,000}{(\frac{h}{t})^2}$
	Stiffened flat webs		4.5	---	4.5	$\frac{h}{t} = 93$	$\frac{39,000}{(\frac{h}{t})^2}$
			9	$\frac{a_e}{t} = 70$	$17.5 - 0.121 \frac{a_e}{t}$	$\frac{a_e}{t} = 96$	$\frac{54,000}{(\frac{a_e}{t})^2}$
			4.5	---	4.5	$\frac{a_e}{t} = 110$	$\frac{54,000}{(\frac{a_e}{t})^2}$

$a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section	Any tension member:	1	14.5	12.5
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	14.5	12.5
	Round or oval tubes	3	17	15
	Rectangular bars, plates, shapes bent about weak axis	4	19	17
BEARING	On rivets and bolts	5	23	19
	On flat surfaces and pins	6	15	13

Table 3.3.16
Allowable Stresses for
BUILDING and Similar
Type Structures
5083-H111
Extrusions

			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	11.5	$\frac{L}{r} = 11$	$12.3 - 0.073 \frac{L}{r}$	$\frac{L}{r} = 113$	$\frac{53,000}{(L/r)^2}$
			11.5	$\frac{L}{r} = 11$	$12.3 - 0.073 \frac{L}{r}$	$\frac{L}{r} = 113$	$\frac{53,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	11.5	$\frac{b}{t} = 6.7$	$14.7 - 0.48 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{2,000}{(b/t)^2}$
			11.5	$\frac{b}{t} = 6.7$	$14.7 - 0.48 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{2,000}{(b/t)^2}$
	Flat plates with both edges supported	9	11.5	$\frac{b}{t} = 21$	$14.7 - 0.151 \frac{b}{t}$	$\frac{b}{t} = 49$	$\frac{360}{(b/t)}$
			11.5	$\frac{b}{t} = 21$	$14.7 - 0.151 \frac{b}{t}$	$\frac{b}{t} = 49$	$\frac{360}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes	10	11.5	$\frac{R}{t} = 26$	$14.2 - 0.53 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 290$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t}/35)^2}$
			11.5	$\frac{R}{t} = 16$	$13.5 - 0.50 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 300$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t}/35)^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	12.5	$\frac{L_b}{r_y} = 28$	$14.5 - 0.072 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 136$	$\frac{90,000}{(L_b/r_y)^2}$
			12.5	$\frac{L_b}{r_y} = 28$	$14.5 - 0.072 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 136$	$\frac{90,000}{(L_b/r_y)^2}$
	Round or oval tubes	12	15	$\frac{R_b}{t} = 47$	$25.2 - 1.48 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 134$	Same as Specification No. 10
			14	$\frac{R_b}{t} = 51$	$23.9 - 1.38 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 140$	Same as Specification No. 10
	Solid rectangular beams	13	17	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 16$	$23.1 - 0.39 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 39$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
			16	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 18$	$23.1 - 0.39 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 39$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
	Rectangular tubes and box sections	14	12.5	$\frac{L_b S_c}{I_y} = 210$	$14.5 - 0.138 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 4990$	$\frac{24,000}{(L_b S_c/I_y)}$
			12.5	$\frac{L_b S_c}{I_y} = 210$	$14.5 - 0.138 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 4990$	$\frac{24,000}{(L_b S_c/I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	12.5	$\frac{b}{t} = 8.4$	$17.3 - 0.57 \frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{132}{(b/t)}$
			12.5	$\frac{b}{t} = 8.4$	$17.3 - 0.57 \frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{132}{(b/t)}$
	Flat plates with both edges supported	16	12.5	$\frac{b}{t} = 27$	$17.3 - 0.178 \frac{b}{t}$	$\frac{b}{t} = 49$	$\frac{420}{(b/t)}$
			12.5	$\frac{b}{t} = 27$	$17.3 - 0.178 \frac{b}{t}$	$\frac{b}{t} = 49$	$\frac{420}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	17	$\frac{b}{t} = 10$	$23.1 - 0.60 \frac{b}{t}$	$\frac{b}{t} = 26$	$\frac{5,100}{(b/t)^2}$
			16	$\frac{b}{t} = 12$	$23.1 - 0.60 \frac{b}{t}$	$\frac{b}{t} = 26$	$\frac{5,100}{(b/t)^2}$
	Flat plates with both edges supported	18	17	$\frac{h}{t} = 53$	$23.1 - 0.115 \frac{h}{t}$	$\frac{h}{t} = 101$	$\frac{1,160}{(h/t)}$
			16	$\frac{h}{t} = 62$	$23.1 - 0.115 \frac{h}{t}$	$\frac{h}{t} = 101$	$\frac{1,160}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported	19	17	$\frac{h}{t} = 122$	$23.1 - 0.050 \frac{h}{t}$	$\frac{h}{t} = 233$	$\frac{2,700}{(h/t)}$
			16	$\frac{h}{t} = 142$	$23.1 - 0.050 \frac{h}{t}$	$\frac{h}{t} = 233$	$\frac{2,700}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	8.5	$\frac{h}{t} = 42$	$11.8 - 0.078 \frac{h}{t}$	$\frac{h}{t} = 101$	$\frac{40,000}{(h/t)^2}$
			7.5	$\frac{h}{t} = 55$	$11.8 - 0.078 \frac{h}{t}$	$\frac{h}{t} = 101$	$\frac{40,000}{(h/t)^2}$
	Stiffened flat webs	21	8.5	$\frac{a_e}{t} = 72$	$16.2 - 0.107 \frac{a_e}{t}$	$\frac{a_e}{t} = 101$	$\frac{55,000}{(a_e/t)^2}$
			7.5	$\frac{a_e}{t} = 81$	$16.2 - 0.107 \frac{a_e}{t}$	$\frac{a_e}{t} = 101$	$\frac{55,000}{(a_e/t)^2}$

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section	Any tension member:	1	19	14.5
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	19	14.5
	Round or oval tubes	3	22	17
	Rectangular bars, plates, shapes bent about weak axis	4	24	19
	On rivets and bolts	5	32	22
BEARING	On flat surfaces and pins	6	21	14.5

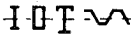
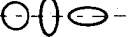
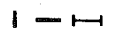
Table 3.3.17
Allowable Stresses for
BUILDING and Similar
Type Structures

5083 – H321

Sheet and Plate
(Thickness – 0.188
to 1.500 in.)

			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	14.5	$\frac{L}{r} = 9.8$	$15.5 - 0.102 \frac{L}{r}$	$\frac{L}{r} = 101$	$\frac{53,000}{(L/r)^2}$
			14.5	$\frac{L}{r} = 9.8$	$15.5 - 0.102 \frac{L}{r}$	$\frac{L}{r} = 101$	$\frac{53,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	14.5	$\frac{b}{t} = 5.9$	$18.5 - 0.68 \frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{2,000}{(b/t)^2}$
			14.5	$\frac{b}{t} = 5.9$	$18.5 - 0.68 \frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{2,000}{(b/t)^2}$
	Flat plates with both edges supported	9	14.5	$\frac{b}{t} = 19$	$18.5 - 0.21 \frac{b}{t}$	$\frac{b}{t} = 43$	$\frac{400}{(b/t)}$
			14.5	$\frac{b}{t} = 19$	$18.5 - 0.21 \frac{b}{t}$	$\frac{b}{t} = 43$	$\frac{400}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes	10	14.5	$\frac{R}{t} = 20$	$17.7 - 0.72 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 235$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
			14.5	$\frac{R}{t} = 7.9$	$16.3 - 0.64 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 250$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	16	$\frac{L_b}{r_y} = 23$	$18.3 - 0.101 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 121$	$\frac{90,000}{(L_b/r_y)^2}$
			16	$\frac{L_b}{r_y} = 23$	$18.3 - 0.101 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 121$	$\frac{90,000}{(L_b/r_y)^2}$
	Round or oval tubes	12	18	$\frac{R_b}{t} = 46$	$31.5 - 1.99 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 118$	Same as Specification No. 10
			17	$\frac{R_b}{t} = 45$	$28.9 - 1.78 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 122$	Same as Specification No. 10
	Solid rectangular beams	13	20	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 16$	$29.2 - 0.56 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 35$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
			19	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 18$	$29.2 - 0.56 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 35$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
	Rectangular tubes and box sections	14	16	$\frac{L_b S_c}{I_y} = 142$	$18.3 - 0.193 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3980$	$\frac{24,000}{(L_b S_c / I_y)}$
			16	$\frac{L_b S_c}{I_y} = 142$	$18.3 - 0.193 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3980$	$\frac{24,000}{(L_b S_c / I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	16	$\frac{b}{t} = 7.3$	$21.9 - 0.81 \frac{b}{t}$	$\frac{b}{t} = 14$	$\frac{149}{(b/t)}$
			16	$\frac{b}{t} = 7.3$	$21.9 - 0.81 \frac{b}{t}$	$\frac{b}{t} = 14$	$\frac{149}{(b/t)}$
	Flat plates with both edges supported	16	16	$\frac{b}{t} = 24$	$21.9 - 0.25 \frac{b}{t}$	$\frac{b}{t} = 43$	$\frac{470}{(b/t)}$
			16	$\frac{b}{t} = 24$	$21.9 - 0.25 \frac{b}{t}$	$\frac{b}{t} = 43$	$\frac{470}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	20	$\frac{b}{t} = 11$	$29.2 - 0.85 \frac{b}{t}$	$\frac{b}{t} = 23$	$\frac{5,100}{(b/t)^2}$
			19	$\frac{b}{t} = 12$	$29.2 - 0.85 \frac{b}{t}$	$\frac{b}{t} = 23$	$\frac{5,100}{(b/t)^2}$
	Flat plates with both edges supported	18	20	$\frac{h}{t} = 56$	$29.2 - 0.163 \frac{h}{t}$	$\frac{h}{t} = 90$	$\frac{1,310}{(h/t)}$
			19	$\frac{h}{t} = 63$	$29.2 - 0.163 \frac{h}{t}$	$\frac{h}{t} = 90$	$\frac{1,310}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported	19	20	$\frac{h}{t} = 131$	$29.2 - 0.070 \frac{h}{t}$	$\frac{h}{t} = 207$	$\frac{3,000}{(h/t)}$
			19	$\frac{h}{t} = 146$	$29.2 - 0.070 \frac{h}{t}$	$\frac{h}{t} = 207$	$\frac{3,000}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	11	$\frac{h}{t} = 38$	$15.5 - 0.118 \frac{h}{t}$	$\frac{h}{t} = 88$	$\frac{40,000}{(h/t)^2}$
			8.5	$\frac{h}{t} = 89$	$15.5 - 0.118 \frac{h}{t}$	$\frac{h}{t} = 88$	$\frac{40,000}{(h/t)^2}$
	Stiffened flat webs	21	11	$\frac{a_e}{t} = 64$	$21.3 - 0.162 \frac{a_e}{t}$	$\frac{a_e}{t} = 88$	$\frac{55,000}{(a_e/t)^2}$
			8.5	$\frac{a_e}{t} = 79$	$21.3 - 0.162 \frac{a_e}{t}$	$\frac{a_e}{t} = 88$	$\frac{55,000}{(a_e/t)^2}$

Table 3.3.17
Allowable Stresses for
BUILDING and Similar
Type Structures
5083-H321
Sheet and Plate
(Thickness—0.188
to 1.500 in.)

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	12.5	11
TENSION IN BEAMS, extreme fiber, net section		Rectangular tubes, structural shapes bent about strong axis 	2	12.5	11
		Round or oval tubes 	3	15	13
		Rectangular bars, plates, shapes bent about weak axis 	4	17	14
BEARING		On rivets and bolts	5	21	17
		On flat surfaces and pins	6	13.5	11.5

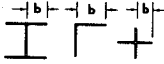
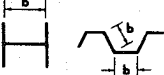
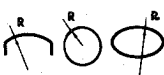
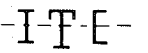
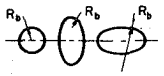
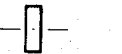
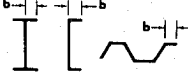
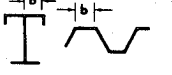
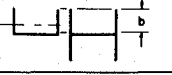
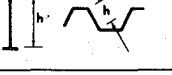
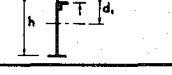
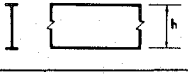
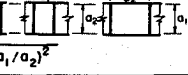
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section		All columns	10	$\frac{L}{r} = 8.8$	$10.5 - 0.057 \frac{L}{r}$	$\frac{L}{r} = 123$	$\frac{53,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section		Outstanding flanges and legs 	10	$\frac{b}{t} = 6.5$	$12.4 - 0.37 \frac{b}{t}$	$\frac{b}{t} = 22$	$\frac{2,000}{(b/t)^2}$
		Flat plates with both edges supported 	10	$\frac{b}{t} = 21$	$12.4 - 0.117 \frac{b}{t}$	$\frac{b}{t} = 53$	$\frac{330}{(b/t)}$
		Curved plates supported on both edges, walls of round or oval tubes 	10	$\frac{R}{t} = 24$	$12.1 - 0.43 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 340$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
			10	$\frac{R}{t} = 12$	$11.4 - 0.40 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 350$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
		Single web beams bent about strong axis 	11	$\frac{L_b}{r_y} = 25$	$12.4 - 0.056 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 148$	$\frac{90,000}{(L_b/r_y)^2}$
		Round or oval tubes 	12	$\frac{R_b}{t} = 50$	$21.4 - 1.19 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 150$	Same as Specification No. 10
COMPRESSION IN BEAMS, extreme fiber, gross section			12	$\frac{R_b}{t} = 54$	$20.1 - 1.10 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 154$	Same as Specification No. 10
		Solid rectangular beams 	13	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 18$	$19.5 - 0.31 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 43$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
			13.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 19$	$19.5 - 0.31 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 43$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
		Rectangular tubes and box sections 	14	$\frac{L_b S_c}{I_y} = 168$	$12.4 - 0.108 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 5910$	$\frac{24,000}{(L_b S_c/I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section		Outstanding flanges 	15	$\frac{b}{t} = 8.4$	$14.7 - 0.44 \frac{b}{t}$	$\frac{b}{t} = 17$	$\frac{122}{(b/t)}$
		Flat plates with both edges supported 	16	$\frac{b}{t} = 27$	$14.7 - 0.139 \frac{b}{t}$	$\frac{b}{t} = 53$	$\frac{390}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section		Flat plates with compression edge free, tension edge supported 	17	$\frac{b}{t} = 12$	$19.5 - 0.46 \frac{b}{t}$	$\frac{b}{t} = 28$	$\frac{5,100}{(b/t)^2}$
		Flat plates with both edges supported 	18	$\frac{h}{t} = 62$	$19.5 - 0.089 \frac{h}{t}$	$\frac{h}{t} = 110$	$\frac{1,070}{(h/t)}$
		Flat plates with horizontal stiffener, both edges supported 	19	$\frac{h}{t} = 145$	$19.5 - 0.038 \frac{h}{t}$	$\frac{h}{t} = 250$	$\frac{2,500}{(h/t)}$
SHEAR IN WEBS, gross section		Unstiffened flat webs 	20	$\frac{h}{t} = 39$	$9.9 - 0.061 \frac{h}{t}$	$\frac{h}{t} = 110$	$\frac{40,000}{(h/t)^2}$
		Stiffened flat webs  $a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$	21	$\frac{a_e}{t} = 75$	$13.7 - 0.083 \frac{a_e}{t}$	$\frac{a_e}{t} = 110$	$\frac{55,000}{(a_e/t)^2}$
			6	$\frac{a_e}{t} = 93$	$13.7 - 0.083 \frac{a_e}{t}$	$\frac{a_e}{t} = 110$	$\frac{55,000}{(a_e/t)^2}$

Table 3.3.18
Allowable Stresses for
BUILDING and Similar
Type Structures
5086 – H111
Extrusions

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.19 Allowable Stresses for BUILDING and Similar Type Structures 5086-H34 Sheet and Plate Drawn Tube			
TENSION, axial, net section	Any tension member:	1	21	11.5				
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	21	11.5				
	Round or oval tubes	3	24	13.5				
	Rectangular bars, plates, shapes bent about weak axis	4	27	15				
BEARING	On rivets and bolts	5	35	17				
	On flat surfaces and pins	6	23	11.5				
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$	
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	18	$\frac{L}{r} = 9.1$	$19.3 - 0.143 \frac{L}{r}$	$\frac{L}{r} = 90$	$\frac{53,000}{(L/r)^2}$	
			11.5	$\frac{L}{r} = 55$	$19.3 - 0.143 \frac{L}{r}$	$\frac{L}{r} = 90$	$\frac{53,000}{(L/r)^2}$	
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	18	$\frac{b}{t} = 5.5$	$23.3 - 0.96 \frac{b}{t}$	$\frac{b}{t} = 16$	$\frac{2,000}{(b/t)^2}$	
			11.5	$\frac{b}{t} = 12$	$23.3 - 0.96 \frac{b}{t}$	$\frac{b}{t} = 16$	$\frac{2,000}{(b/t)^2}$	
	Flat plates with both edges supported	9	18	$\frac{b}{t} = 18$	$23.3 - 0.30 \frac{b}{t}$	$\frac{b}{t} = 39$	$\frac{450}{(b/t)}$	
			11.5	---	11.5	$\frac{b}{t} = 39$	$\frac{450}{(b/t)}$	
	Curved plates supported on both edges, walls of round or oval tubes	10	18	$\frac{R}{t} = 18$	$22.1 - 0.96 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 192$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$	
			11.5	$\frac{R}{t} = 8.0$	$12.8 - 0.46 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 320$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$	
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	19	$\frac{L_b}{r_y} = 27$	$22.8 - 0.140 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 108$	$\frac{90,000}{(L_b/r_y)^2}$	
			11.5	$\frac{L_b}{r_y} = 81$	$22.8 - 0.140 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 108$	$\frac{90,000}{(L_b/r_y)^2}$	
	Round or oval tubes	12	23	$\frac{R_b}{t} = 36$	$39.2 - 2.7 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 97$	Same as Specification No. 10	
			13.5	$\frac{R_b}{t} = 52$	$22.7 - 1.28 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 146$	Same as Specification No. 10	
	Solid rectangular beams	13	25	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 15$	$36.7 - 0.79 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 31$	$\frac{11,800}{(d/t)^2 (L_b/d)}$	
			15	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 27$	$36.7 - 0.79 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 31$	$\frac{11,800}{(d/t)^2 (L_b/d)}$	
	Rectangular tubes and box sections	14	19	$\frac{L_b S_c}{I_y} = 198$	$22.8 - 0.27 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3160$	$\frac{24,000}{(L_b S_c/I_y)}$	
			11.5	$\frac{L_b S_c}{I_y} = 1750$	$22.8 - 0.27 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3160$	$\frac{24,000}{(L_b S_c/I_y)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	19	$\frac{b}{t} = 7.5$	$27.5 - 1.13 \frac{b}{t}$	$\frac{b}{t} = 12$	$\frac{167}{(b/t)}$	
			11.5	---	11.5	$\frac{b}{t} = 15$	$\frac{167}{(b/t)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with both edges supported	16	19	$\frac{b}{t} = 24$	$27.5 - 0.36 \frac{b}{t}$	$\frac{b}{t} = 39$	$\frac{530}{(b/t)}$	
			11.5	---	11.5	$\frac{b}{t} = 46$	$\frac{530}{(b/t)}$	
	Flat plates with compression edge free, tension edge supported	17	25	$\frac{b}{t} = 9.7$	$36.7 - 1.20 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{5,100}{(b/t)^2}$	
			15	$\frac{b}{t} = 18$	$36.7 - 1.20 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{5,100}{(b/t)^2}$	
	Flat plates with both edges supported	18	25	$\frac{h}{t} = 51$	$36.7 - 0.23 \frac{h}{t}$	$\frac{h}{t} = 80$	$\frac{1,460}{(h/t)}$	
			15	---	15	$\frac{h}{t} = 97$	$\frac{1,460}{(h/t)}$	
Flat plates with horizontal stiffener, both edges supported	19	25	$\frac{h}{t} = 118$	$36.7 - 0.099 \frac{h}{t}$	$\frac{h}{t} = 185$	$\frac{3,400}{(h/t)}$		
		15	---	15	$\frac{h}{t} = 227$	$\frac{3,400}{(h/t)}$		
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	12	$\frac{h}{t} = 39$	$17.5 - 0.140 \frac{h}{t}$	$\frac{h}{t} = 83$	$\frac{40,000}{(h/t)^2}$	
			6.5	---	6.5	$\frac{h}{t} = 78$	$\frac{40,000}{(h/t)^2}$	
	Stiffened flat webs	21	12	$\frac{a_e}{t} = 62$	$24.0 - 0.193 \frac{a_e}{t}$	$\frac{a_e}{t} = 83$	$\frac{55,000}{(a_e/t)^2}$	
6.5			---	6.5	$\frac{a_e}{t} = 92$	$\frac{55,000}{(a_e/t)^2}$		

Table 3.3.19
Allowable Stresses for
BUILDING and Similar
Type Structures
5086-H34
Sheet and Plate
Drawn Tube

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	11.5	9.5
		Rectangular tubes, structural shapes bent about strong axis	2	11.5	9.5
		Round or oval tubes	3	13.5	11.5
		Rectangular bars, plates, shapes bent about weak axis	4	15	12.5
BEARING		On rivets and bolts	5	18	14.5
		On flat surfaces and pins	6	12	9.5

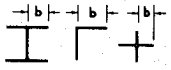
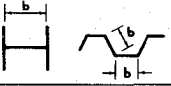
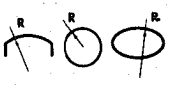
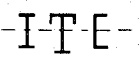
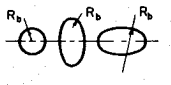
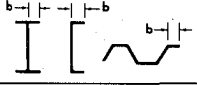
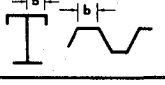
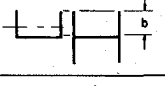
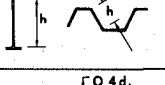
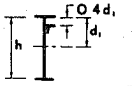
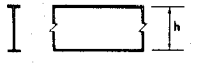
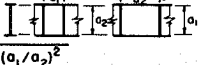
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		9	$\frac{L}{r} = 4.3$	$9.2-0.047\frac{L}{r}$	$\frac{L}{r} = 131$	$\frac{53,000}{(L/r)^2}$
			9	$\frac{L}{r} = 4.3$	$9.2-0.047\frac{L}{r}$	$\frac{L}{r} = 131$	$\frac{53,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs		9	$\frac{b}{t} = 6.1$	$10.9-0.31\frac{b}{t}$	$\frac{b}{t} = 24$	$\frac{2,000}{(b/t)^2}$
			9	$\frac{b}{t} = 6.1$	$10.9-0.31\frac{b}{t}$	$\frac{b}{t} = 24$	$\frac{2,000}{(b/t)^2}$
	Flat plates with both edges supported		9	$\frac{b}{t} = 20$	$10.9-0.097\frac{b}{t}$	$\frac{b}{t} = 56$	$\frac{310}{(b/t)}$
			9	$\frac{b}{t} = 20$	$10.9-0.097\frac{b}{t}$	$\frac{b}{t} = 56$	$\frac{310}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes		9	$\frac{R}{t} = 22$	$10.7-0.36\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 370$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
			9	$\frac{R}{t} = 7.4$	$9.9-0.33\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 410$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis		9.5	$\frac{L_b}{r_y} = 30$	$10.9-0.046\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 157$	$\frac{90,000}{(L_b/r_y)^2}$
			9.5	$\frac{L_b}{r_y} = 30$	$10.9-0.046\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 157$	$\frac{90,000}{(L_b/r_y)^2}$
	Round or oval tubes		11.5	$\frac{R_b}{t} = 54$	$18.9-1.01\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 159$	Same as Specification No. 10
			10.5	$\frac{R_b}{t} = 61$	$17.7-0.92\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 175$	Same as Specification No. 10
	Solid rectangular beams		12.5	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 19$	$17.2-0.25\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 45$	$\frac{11,800}{(d/t)^2(L_b/d)}$
			12	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 21$	$17.2-0.25\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 45$	$\frac{11,800}{(d/t)^2(L_b/d)}$
	Rectangular tubes and box sections		9.5	$\frac{L_b S_c}{I_y} = 247$	$10.9-0.089\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 6700$	$\frac{24,000}{(L_b S_c/I_y)}$
			9.5	$\frac{L_b S_c}{I_y} = 247$	$10.9-0.089\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 6700$	$\frac{24,000}{(L_b S_c/I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges		9.5	$\frac{b}{t} = 9.4$	$12.9-0.36\frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{114}{(b/t)}$
			9.5	$\frac{b}{t} = 9.4$	$12.9-0.36\frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{114}{(b/t)}$
	Flat plates with both edges supported		9.5	$\frac{b}{t} = 30$	$12.9-0.114\frac{b}{t}$	$\frac{b}{t} = 56$	$\frac{360}{(b/t)}$
			9.5	$\frac{b}{t} = 30$	$12.9-0.114\frac{b}{t}$	$\frac{b}{t} = 56$	$\frac{360}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported		12.5	$\frac{b}{t} = 12$	$17.2-0.38\frac{b}{t}$	$\frac{b}{t} = 30$	$\frac{5,100}{(b/t)^2}$
			12	$\frac{b}{t} = 14$	$17.2-0.38\frac{b}{t}$	$\frac{b}{t} = 30$	$\frac{5,100}{(b/t)^2}$
	Flat plates with both edges supported		12.5	$\frac{h}{t} = 64$	$17.2-0.073\frac{h}{t}$	$\frac{h}{t} = 117$	$\frac{1,000}{(h/t)}$
			12	$\frac{h}{t} = 71$	$17.2-0.073\frac{h}{t}$	$\frac{h}{t} = 117$	$\frac{1,000}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported		12.5	$\frac{h}{t} = 147$	$17.2-0.032\frac{h}{t}$	$\frac{h}{t} = 270$	$\frac{2,300}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs		6.5	$\frac{h}{t} = 48$	$9.0-0.052\frac{h}{t}$	$\frac{h}{t} = 115$	$\frac{40,000}{(h/t)^2}$
			6	$\frac{h}{t} = 58$	$9.0-0.052\frac{h}{t}$	$\frac{h}{t} = 115$	$\frac{40,000}{(h/t)^2}$
	Stiffened flat webs		6.5	$\frac{a_e}{t} = 82$	$12.4-0.072\frac{a_e}{t}$	$\frac{a_e}{t} = 115$	$\frac{55,000}{(a_e/t)^2}$
			6	$\frac{a_e}{t} = 89$	$12.4-0.072\frac{a_e}{t}$	$\frac{a_e}{t} = 115$	$\frac{55,000}{(a_e/t)^2}$

Table 3.3.20
Allowable Stresses for
BUILDING and Similar
Type Structures
5454—H111
Extrusions

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Table 3.3.21
Allowable Stresses for
BUILDING and Similar
Type Structures
5454 – H34
Sheet and Plate

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.21 Allowable Stresses for BUILDING and Similar Type Structures 5454 – H34 Sheet and Plate		
TENSION, axial, net section		Any tension member:	1	18	9.5			
TENSION IN BEAMS, extreme fiber, net section		Rectangular tubes, structural shapes bent about strong axis	2	18	9.5			
		Round or oval tubes	3	21	11.5			
		Rectangular bars, plates, shapes bent about weak axis	4	23	12.5			
BEARING		On rivets and bolts	5	30	14.5			
		On flat surfaces and pins	6	20	9.5			
				Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section		All columns	7	15	$\frac{L}{r} = 10$	$16.1-0.109\frac{L}{r}$	$\frac{L}{r} = 99$	$\frac{53,000}{(\frac{L}{r})^2}$
				9.5	$\frac{L}{r} = 61$	$16.1-0.109\frac{L}{r}$	$\frac{L}{r} = 99$	$\frac{53,000}{(\frac{L}{r})^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section		Outstanding flanges and legs	8	15	$\frac{b}{t} = 5.9$	$19.3-0.73\frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{2,000}{(\frac{b}{t})^2}$
				9.5	$\frac{b}{t} = 13$	$19.3-0.73\frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{2,000}{(\frac{b}{t})^2}$
		Flat plates with both edges supported	9	15	$\frac{b}{t} = 19$	$19.3-0.23\frac{b}{t}$	$\frac{b}{t} = 42$	$\frac{410}{(\frac{b}{t})}$
				9.5	---	9.5	$\frac{b}{t} = 43$	$\frac{410}{(\frac{b}{t})}$
		Curved plates supported on both edges, walls of round or oval tubes	10	15	$\frac{R}{t} = 22$	$18.5-0.75\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 226$	$\frac{3,300}{(\frac{R}{t})(1 + \sqrt{R/t/35})^2}$
				9.5	$\frac{R}{t} = 11$	$10.7-0.36\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 370$	$\frac{3,300}{(\frac{R}{t})(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section		Single web beams bent about strong axis	11	16	$\frac{L_b}{r_y} = 28$	$19.0-0.107\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 119$	$\frac{90,000}{(\frac{L_b}{r_y})^2}$
				9.5	$\frac{L_b}{r_y} = 89$	$19.0-0.107\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 119$	$\frac{90,000}{(\frac{L_b}{r_y})^2}$
		Round or oval tubes	12	19	$\frac{R_b}{t} = 43$	$32.7-2.10\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 111$	Same as Specification No. 10
				11.5	$\frac{R_b}{t} = 54$	$18.9-1.01\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 159$	Same as Specification No. 10
		Solid rectangular beams	13	21	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 16$	$30.4-0.59\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 34$	$\frac{11,800}{(\frac{d}{t})^2(\frac{L_b}{d})}$
				12.5	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 30$	$30.4-0.59\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 34$	$\frac{11,800}{(\frac{d}{t})^2(\frac{L_b}{d})}$
		Rectangular tubes and box sections	14	16	$\frac{L_b S_c}{I_y} = 204$	$19.0-0.21\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3830$	$\frac{24,000}{(\frac{L_b S_c}{I_y})}$
				9.5	$\frac{L_b S_c}{I_y} = 2050$	$19.0-0.21\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3830$	$\frac{24,000}{(\frac{L_b S_c}{I_y})}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section		Outstanding flanges	15	16	$\frac{b}{t} = 7.9$	$22.8-0.86\frac{b}{t}$	$\frac{b}{t} = 13$	$\frac{152}{(\frac{b}{t})}$
				9.5	---	9.5	$\frac{b}{t} = 16$	$\frac{152}{(\frac{b}{t})}$
		Flat plates with both edges supported	16	16	$\frac{b}{t} = 25$	$22.8-0.27\frac{b}{t}$	$\frac{b}{t} = 42$	$\frac{480}{(\frac{b}{t})}$
				9.5	---	9.5	$\frac{b}{t} = 51$	$\frac{480}{(\frac{b}{t})}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section		Flat plates with compression edge free, tension edge supported	17	21	$\frac{b}{t} = 10$	$30.4-0.90\frac{b}{t}$	$\frac{b}{t} = 22$	$\frac{5,100}{(\frac{b}{t})^2}$
				12.5	$\frac{b}{t} = 20$	$30.4-0.90\frac{b}{t}$	$\frac{b}{t} = 22$	$\frac{5,100}{(\frac{b}{t})^2}$
		Flat plates with both edges supported	18	21	$\frac{h}{t} = 54$	$30.4-0.173\frac{h}{t}$	$\frac{h}{t} = 88$	$\frac{1,330}{(\frac{h}{t})}$
				12.5	---	12.5	$\frac{h}{t} = 106$	$\frac{1,330}{(\frac{h}{t})}$
		Flat plates with horizontal stiffener, both edges supported	19	21	$\frac{h}{t} = 125$	$30.4-0.075\frac{h}{t}$	$\frac{h}{t} = 203$	$\frac{3,100}{(\frac{h}{t})}$
				12.5	---	12.5	$\frac{h}{t} = 248$	$\frac{3,100}{(\frac{h}{t})}$
SHEAR IN WEBS, gross section		Unstiffened flat webs	20	10.5	$\frac{h}{t} = 38$	$14.6-0.108\frac{h}{t}$	$\frac{h}{t} = 90$	$\frac{40,000}{(\frac{h}{t})^2}$
				6	$\frac{h}{t} = 80$	$14.6-0.108\frac{h}{t}$	$\frac{h}{t} = 90$	$\frac{40,000}{(\frac{h}{t})^2}$
		Stiffened flat webs	21	10.5	$\frac{a_e}{t} = 65$	$20.1-0.148\frac{a_e}{t}$	$\frac{a_e}{t} = 90$	$\frac{55,000}{(\frac{a_e}{t})^2}$
				6	---	6	$\frac{a_e}{t} = 96$	$\frac{55,000}{(\frac{a_e}{t})^2}$

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	16	14.5
		Rectangular tubes, structural shapes bent about strong axis	2	16	14.5
		Round or oval tubes	3	18	17
		Rectangular bars, plates, shapes bent about weak axis	4	20	19
BEARING		On rivets and bolts	5	25	23
		On flat surfaces and pins	6	17	15

			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi, Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi, Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section		All columns	12	$\frac{L}{r} = 13$	$13.0 - 0.078 \frac{L}{r}$	$\frac{L}{r} = 110$	$\frac{53,000}{(L/r)^2}$
			12	$\frac{L}{r} = 13$	$13.0 - 0.078 \frac{L}{r}$	$\frac{L}{r} = 110$	$\frac{53,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section		Outstanding flanges and legs	12	$\frac{b}{t} = 6.5$	$15.4 - 0.52 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{2,000}{(b/t)^2}$
			12	$\frac{b}{t} = 6.5$	$15.4 - 0.52 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{2,000}{(b/t)^2}$
		Flat plates with both edges supported	12	$\frac{b}{t} = 21$	$15.4 - 0.162 \frac{b}{t}$	$\frac{b}{t} = 48$	$\frac{370}{(b/t)}$
			12	$\frac{b}{t} = 21$	$15.4 - 0.162 \frac{b}{t}$	$\frac{b}{t} = 48$	$\frac{370}{(b/t)}$
		Curved plates supported on both edges, walls of round or oval tubes	12	$\frac{R}{t} = 26$	$14.9 - 0.57 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 280$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
			12	$\frac{R}{t} = 26$	$14.9 - 0.57 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 280$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section		Single web beams bent about strong axis	11	$\frac{L_b}{r_y} = 23$	$15.3 - 0.077 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 132$	$\frac{90,000}{(L_b/r_y)^2}$
			13.5	$\frac{L_b}{r_y} = 23$	$15.3 - 0.077 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 132$	$\frac{90,000}{(L_b/r_y)^2}$
		Round or oval tubes	12	$\frac{R_b}{t} = 43$	$26.4 - 1.58 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 130$	Same as Specification No. 10
			16	$\frac{R_b}{t} = 43$	$26.4 - 1.58 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 130$	Same as Specification No. 10
		Solid rectangular beams	13	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 17$	$24.2 - 0.42 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 38$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
			17	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 17$	$24.2 - 0.42 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 38$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
		Rectangular tubes and box sections	14	$\frac{L_b S_c}{I_y} = 150$	$15.3 - 0.147 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 4730$	$\frac{24,000}{(L_b S_c / I_y)}$
			13.5	$\frac{L_b S_c}{I_y} = 150$	$15.3 - 0.147 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 4730$	$\frac{24,000}{(L_b S_c / I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section		Outstanding flanges	15	$\frac{b}{t} = 7.7$	$18.2 - 0.61 \frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{136}{(b/t)}$
			13.5	$\frac{b}{t} = 7.7$	$18.2 - 0.61 \frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{136}{(b/t)}$
		Flat plates with both edges supported	16	$\frac{b}{t} = 24$	$18.2 - 0.192 \frac{b}{t}$	$\frac{b}{t} = 48$	$\frac{430}{(b/t)}$
			13.5	$\frac{b}{t} = 24$	$18.2 - 0.192 \frac{b}{t}$	$\frac{b}{t} = 48$	$\frac{430}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section		Flat plates with compression edge free, tension edge supported	17	$\frac{b}{t} = 11$	$24.2 - 0.64 \frac{b}{t}$	$\frac{b}{t} = 25$	$\frac{5,100}{(b/t)^2}$
			17	$\frac{b}{t} = 11$	$24.2 - 0.64 \frac{b}{t}$	$\frac{b}{t} = 25$	$\frac{5,100}{(b/t)^2}$
		Flat plates with both edges supported	18	$\frac{h}{t} = 59$	$24.2 - 0.123 \frac{h}{t}$	$\frac{h}{t} = 98$	$\frac{1,190}{(h/t)}$
			17	$\frac{h}{t} = 59$	$24.2 - 0.123 \frac{h}{t}$	$\frac{h}{t} = 98$	$\frac{1,190}{(h/t)}$
		Flat plates with horizontal stiffener, both edges supported	19	$\frac{h}{t} = 136$	$24.2 - 0.053 \frac{h}{t}$	$\frac{h}{t} = 227$	$\frac{2,700}{(h/t)}$
			17	$\frac{h}{t} = 136$	$24.2 - 0.053 \frac{h}{t}$	$\frac{h}{t} = 227$	$\frac{2,700}{(h/t)}$
SHEAR IN WEBS, gross section		Unstiffened flat webs	20	$\frac{h}{t} = 43$	$12.7 - 0.087 \frac{h}{t}$	$\frac{h}{t} = 97$	$\frac{40,000}{(h/t)^2}$
			8.5	$\frac{h}{t} = 48$	$12.7 - 0.087 \frac{h}{t}$	$\frac{h}{t} = 97$	$\frac{40,000}{(h/t)^2}$
		Stiffened flat webs	21	$\frac{a_e}{t} = 71$	$17.5 - 0.120 \frac{a_e}{t}$	$\frac{a_e}{t} = 97$	$\frac{55,000}{(a_e/t)^2}$
		$a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$	8.5	$\frac{a_e}{t} = 75$	$17.5 - 0.120 \frac{a_e}{t}$	$\frac{a_e}{t} = 97$	$\frac{55,000}{(a_e/t)^2}$

Table 3.3.22
Allowable Stresses for
BUILDING and Similar
Type Structures
5456—H111
Extrusions

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	20	16
		Rectangular tubes, structural shapes bent about strong axis	2	20	16
		Round or oval tubes	3	23	18
		Rectangular bars, plates, shapes bent about weak axis	4	26	20
TENSION IN BEAMS, extreme fiber, net section					
BEARING		On rivets and bolts	5	34	23
		On flat surfaces and pins	6	23	15

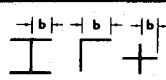
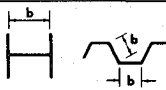
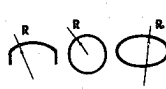
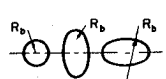
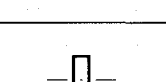
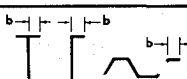
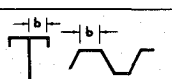
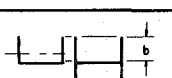
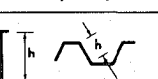
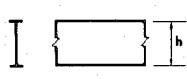
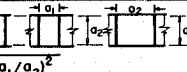
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		15	$\frac{L}{r} = 10$	$16.1 - 0.109 \frac{L}{r}$	$\frac{L}{r} = 99$	$\frac{53,000}{(L/r)^2}$
			14.5	$\frac{L}{r} = 15$	$16.1 - 0.109 \frac{L}{r}$	$\frac{L}{r} = 99$	$\frac{53,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs		15	$\frac{b}{t} = 5.9$	$19.3 - 0.73 \frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{2,000}{(b/t)^2}$
			14.5	$\frac{b}{t} = 6.6$	$19.3 - 0.73 \frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{2,000}{(b/t)^2}$
	Flat plates with both edges supported		15	$\frac{b}{t} = 19$	$19.3 - 0.23 \frac{b}{t}$	$\frac{b}{t} = 42$	$\frac{410}{(b/t)}$
			14.5	$\frac{b}{t} = 21$	$19.3 - 0.23 \frac{b}{t}$	$\frac{b}{t} = 42$	$\frac{410}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes		15	$\frac{R}{t} = 22$	$18.5 - 0.75 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 226$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
			14.5	$\frac{R}{t} = 7.9$	$16.3 - 0.64 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 250$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis		16	$\frac{L_b}{r_y} = 28$	$19.0 - 0.107 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 119$	$\frac{90,000}{(L_b/r_y)^2}$
			14.5	$\frac{L_b}{r_y} = 42$	$19.0 - 0.107 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 119$	$\frac{90,000}{(L_b/r_y)^2}$
	Round or oval tubes		19	$\frac{R_b}{t} = 43$	$32.7 - 2.10 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 111$	Same as Specification No. 10
			17	$\frac{R_b}{t} = 45$	$28.9 - 1.78 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 122$	Same as Specification No. 10
	Solid rectangular beams		21	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 16$	$30.4 - 0.59 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 34$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
			19	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 19$	$30.4 - 0.59 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 34$	$\frac{11,800}{(d/t)^2 (L_b/d)}$
	Rectangular tubes and box sections		16	$\frac{L_b S_c}{I_y} = 204$	$19.0 - 0.21 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3830$	$\frac{24,000}{(L_b S_c / I_y)}$
			14.5	$\frac{L_b S_c}{I_y} = 460$	$19.0 - 0.21 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3830$	$\frac{24,000}{(L_b S_c / I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges		16	$\frac{b}{t} = 7.9$	$22.8 - 0.86 \frac{b}{t}$	$\frac{b}{t} = 13$	$\frac{152}{(b/t)}$
			14.5	$\frac{b}{t} = 9.7$	$22.8 - 0.86 \frac{b}{t}$	$\frac{b}{t} = 13$	$\frac{152}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported		21	$\frac{b}{t} = 10$	$30.4 - 0.90 \frac{b}{t}$	$\frac{b}{t} = 22$	$\frac{5,100}{(b/t)^2}$
			19	$\frac{b}{t} = 13$	$30.4 - 0.90 \frac{b}{t}$	$\frac{b}{t} = 22$	$\frac{5,100}{(b/t)^2}$
	Flat plates with both edges supported		21	$\frac{h}{t} = 54$	$30.4 - 0.173 \frac{h}{t}$	$\frac{h}{t} = 88$	$\frac{1,330}{(h/t)}$
			19	$\frac{h}{t} = 66$	$30.4 - 0.173 \frac{h}{t}$	$\frac{h}{t} = 88$	$\frac{1,330}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported		21	$\frac{h}{t} = 125$	$30.4 - 0.075 \frac{h}{t}$	$\frac{h}{t} = 203$	$\frac{3,100}{(h/t)}$
			19	$\frac{h}{t} = 152$	$30.4 - 0.075 \frac{h}{t}$	$\frac{h}{t} = 203$	$\frac{3,100}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs		11.5	$\frac{h}{t} = 39$	$16.5 - 0.129 \frac{h}{t}$	$\frac{h}{t} = 86$	$\frac{40,000}{(h/t)^2}$
			9	$\frac{h}{t} = 58$	$16.5 - 0.129 \frac{h}{t}$	$\frac{h}{t} = 86$	$\frac{40,000}{(h/t)^2}$
	Stiffened flat webs		11.5	$\frac{a_e}{t} = 63$	$22.7 - 0.177 \frac{a_e}{t}$	$\frac{a_e}{t} = 86$	$\frac{55,000}{(a_e/t)^2}$
			9	$\frac{a_e}{t} = 77$	$22.7 - 0.177 \frac{a_e}{t}$	$\frac{a_e}{t} = 86$	$\frac{55,000}{(a_e/t)^2}$

Table 3.3.23
Allowable Stresses for
BUILDING and Similar
Type Structures
5456 – H321
Sheet and Plate
(Thickness – 0.188
to 1.250 in.)

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	25	16
TENSION IN BEAMS, extreme fiber, net section		Rectangular tubes, structural shapes bent about strong axis	2	25	16
		Round or oval tubes	3	29	18
		Rectangular bars, plates, shapes bent about weak axis	4	32	20
BEARING		On rivets and bolts	5	42	23
		On flat surfaces and pins	6	28	15

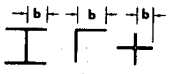
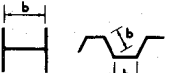
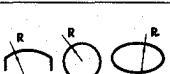
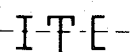
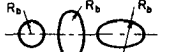
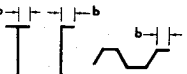
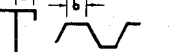
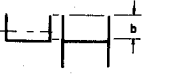
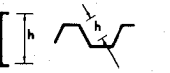
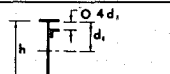
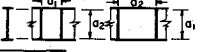
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		21	$\frac{L}{r} = 15$	$23.9-0.196\frac{L}{r}$	$\frac{L}{r} = 81$	$\frac{53,000}{(\frac{L}{r})^2}$
			16	$\frac{L}{r} = 40$	$23.9-0.196\frac{L}{r}$	$\frac{L}{r} = 81$	$\frac{53,000}{(\frac{L}{r})^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs		21	$\frac{b}{t} = 5.9$	$28.9-1.33\frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{2,000}{(\frac{b}{t})^2}$
			16	$\frac{b}{t} = 9.7$	$28.9-1.33\frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{2,000}{(\frac{b}{t})^2}$
	Flat plates with both edges supported		21	$\frac{b}{t} = 19$	$28.9-0.42\frac{b}{t}$	$\frac{b}{t} = 35$	$\frac{500}{(\frac{b}{t})}$
			16	$\frac{b}{t} = 31$	$28.9-0.42\frac{b}{t}$	$\frac{b}{t} = 35$	$\frac{500}{(\frac{b}{t})}$
	Curved plates supported on both edges, walls of round or oval tubes		21	$\frac{R}{t} = 24$	$27.2-1.26\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 157$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
			16	$\frac{R}{t} = 5.6$	$17.7-0.72\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 235$	$\frac{3,300}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis		24	$\frac{L_b}{r_y} = 22$	$28.3-0.193\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 97$	$\frac{90,000}{(\frac{L_b}{r_y})^2}$
			16	$\frac{L_b}{r_y} = 64$	$28.3-0.193\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 97$	$\frac{90,000}{(\frac{L_b}{r_y})^2}$
	Round or oval tubes		28	$\frac{R_b}{t} = 33$	$48.2-3.50\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 88$	Same as Specification No. 10
			18	$\frac{R_b}{t} = 46$	$31.5-1.99\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 118$	Same as Specification No. 10
	Solid rectangular beams		31	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 13$	$45.6-1.09\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 28$	$\frac{11,800}{(d/t)^2(L_b/d)}$
			20	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 23$	$45.6-1.09\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 28$	$\frac{11,800}{(d/t)^2(L_b/d)}$
	Rectangular tubes and box sections		24	$\frac{L_b S_r}{I_y} = 135$	$28.3-0.37\sqrt{\frac{L_b S_r}{I_y}}$	$\frac{L_b S_r}{I_y} = 2560$	$\frac{24,000}{(L_b S_r/I_y)}$
			16	$\frac{L_b S_r}{I_y} = 1110$	$28.3-0.37\sqrt{\frac{L_b S_r}{I_y}}$	$\frac{L_b S_r}{I_y} = 2560$	$\frac{24,000}{(L_b S_r/I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges		24	$\frac{b}{t} = 6.5$	$34.2-1.57\frac{b}{t}$	$\frac{b}{t} = 11$	$\frac{186}{(\frac{b}{t})}$
			16	---	16	$\frac{b}{t} = 12$	$\frac{186}{(\frac{b}{t})}$
	Flat plates with both edges supported		24	$\frac{b}{t} = 21$	$34.2-0.49\frac{b}{t}$	$\frac{b}{t} = 35$	$\frac{590}{(\frac{b}{t})}$
			16	---	16	$\frac{b}{t} = 37$	$\frac{590}{(\frac{b}{t})}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported		31	$\frac{b}{t} = 8.8$	$45.6-1.66\frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{5,100}{(\frac{b}{t})^2}$
			20	$\frac{b}{t} = 15$	$45.6-1.66\frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{5,100}{(\frac{b}{t})^2}$
	Flat plates with both edges supported		31	$\frac{h}{t} = 46$	$45.6-0.32\frac{h}{t}$	$\frac{h}{t} = 72$	$\frac{1,630}{(\frac{h}{t})}$
			20	---	20	$\frac{h}{t} = 82$	$\frac{1,630}{(\frac{h}{t})}$
	Flat plates with horizontal stiffener, both edges supported		31	$\frac{h}{t} = 106$	$45.6-0.138\frac{h}{t}$	$\frac{h}{t} = 166$	$\frac{3,800}{(\frac{h}{t})}$
			20	---	20	$\frac{h}{t} = 190$	$\frac{3,800}{(\frac{h}{t})}$
SHEAR IN WEBS, gross section	Unstiffened flat webs		14.5	$\frac{h}{t} = 36$	$21.3-0.189\frac{h}{t}$	$\frac{h}{t} = 75$	$\frac{40,000}{(\frac{h}{t})^2}$
			9	$\frac{h}{t} = 65$	$21.3-0.189\frac{h}{t}$	$\frac{h}{t} = 75$	$\frac{40,000}{(\frac{h}{t})^2}$
	Stiffened flat webs		14.5	$\frac{a_e}{t} = 57$	$29.3-0.26\frac{a_e}{t}$	$\frac{a_e}{t} = 75$	$\frac{55,000}{(\frac{a_e}{t})^2}$
			9	---	9	$\frac{a_e}{t} = 78$	$\frac{55,000}{(\frac{a_e}{t})^2}$

Table 3.3.24
Allowable Stresses for
BUILDING and Similar
Type Structures
5456-H343
Sheet

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.25 Allowable Stresses for BUILDING and Similar Type Structures 6061-T6, -T651, -T6510, -T6511 Extrusions, Sheet and Plate, Standard Structural Shapes, Rolled Rod and Bar Drawn Tube, Pipe			
TENSION, axial, net section		Any tension member:	1	19	11 [⊙]				
TENSION IN BEAMS, extreme fiber, net section		Rectangular tubes, structural shapes bent about strong axis	2	19	11 [⊙]				
		Round or oval tubes	3	24	13.5 [⊙]				
		Rectangular bars, plates, shapes bent about weak axis	4	28	16 [⊙]				
BEARING		On rivets and bolts	5	34	18 [⊙]				
		On flat surfaces and pins	6	23	12 [⊙]				
				Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi, Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi, Slenderness $\geq S_2$	
COMPRESSION IN COLUMNS, axial, gross section		All columns	7	19	$\frac{L}{r} = 9.5$	$20.2-0.126\frac{L}{r}$	$\frac{L}{r} = 66$	$\frac{51,000}{(L/r)^2}$	
				12 [⊙]	---	12 [⊙]	$\frac{L}{r} = 65^{\circ}$	$\frac{51,000}{(L/r)^2}$	
COMPRESSION IN COMPONENTS OF COLUMNS, gross section		Outstanding flanges and legs	8	19	$\frac{b}{t} = 5.2$	$23.1-0.79\frac{b}{t}$	$\frac{b}{t} = 12$	$\frac{1,970}{(b/t)^2}$	
				12 [⊙]	---	12 [⊙]	$\frac{b}{t} = 13^{\circ}$	$\frac{1,970}{(b/t)^2}$	
		Flat plates with both edges supported	9	19	$\frac{b}{t} = 16$	$23.1-0.25\frac{b}{t}$	$\frac{b}{t} = 33$	$\frac{490}{(b/t)}$	
				12 [⊙]	---	12 [⊙]	$\frac{b}{t} = 41^{\circ}$	$\frac{490}{(b/t)}$	
		Curved plates supported on both edges, walls of round or oval tubes	10	19	$\frac{R}{t} = 16$	$22.2-0.80\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 141$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$	
				12 [⊙]	$\frac{R}{t} = 9.0^{\circ}$	$13.5-0.50\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 290$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$	
COMPRESSION IN BEAMS, extreme fiber, gross section		Single web beams bent about strong axis	11	21	$\frac{L_b}{r_y} = 23$	$23.9-0.124\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 79$	$\frac{87,000}{(L_b/r_y)^2}$	
				12 [⊙]	---	12 [⊙]	$\frac{L_b}{r_y} = 85^{\circ}$	$\frac{87,000}{(L_b/r_y)^2}$	
		Round or oval tubes	12	25	$\frac{R_b}{t} = 28$	$39.3-2.7\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 81$	Same as Specification No. 10	
				14 [⊙]	$\frac{R_b}{t} = 51^{\circ}$	$23.9-1.39\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 137$	Same as Specification No. 10	
		Solid rectangular beams	13	28	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 13$	$40.5-0.93\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 29$	$\frac{11,400}{(d/t)^2(L_b/d)}$	
				16 [⊙]	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 26^{\circ}$	$40.5-0.93\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 29$	$\frac{11,400}{(d/t)^2(L_b/d)}$	
		Rectangular tubes and box sections	14	21	$\frac{L_b S_c}{I_y} = 146$	$23.9-0.24\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 1700$	$\frac{24,000}{(L_b S_c/I_y)}$	
				12 [⊙]	---	12 [⊙]	$\frac{L_b S_c}{I_y} = 2000^{\circ}$	$\frac{24,000}{(L_b S_c/I_y)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section		Outstanding flanges	15	21	$\frac{b}{t} = 6.8$	$27.3-0.93\frac{b}{t}$	$\frac{b}{t} = 10$	$\frac{182}{(b/t)}$	
				12 [⊙]	---	12 [⊙]	$\frac{b}{t} = 15^{\circ}$	$\frac{182}{(b/t)}$	
		Flat plates with both edges supported	16	21	$\frac{b}{t} = 22$	$27.3-0.29\frac{b}{t}$	$\frac{b}{t} = 33$	$\frac{580}{(b/t)}$	
				12 [⊙]	---	12 [⊙]	$\frac{b}{t} = 48^{\circ}$	$\frac{580}{(b/t)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section		Flat plates with compression edge free, tension edge supported	17	28	$\frac{b}{t} = 8.9$	$40.5-1.41\frac{b}{t}$	$\frac{b}{t} = 19$	$\frac{4,900}{(b/t)^2}$	
				16 [⊙]	$\frac{b}{t} = 17^{\circ}$	$40.5-1.41\frac{b}{t}$	$\frac{b}{t} = 19$	$\frac{4,900}{(b/t)^2}$	
		Flat plates with both edges supported	18	28	$\frac{h}{t} = 46$	$40.5-0.27\frac{h}{t}$	$\frac{h}{t} = 75$	$\frac{1,520}{(h/t)}$	
				16 [⊙]	---	16 [⊙]	$\frac{h}{t} = 95^{\circ}$	$\frac{1,520}{(h/t)}$	
		Flat plates with horizontal stiffener, both edges supported	19	28	$\frac{h}{t} = 107$	$40.5-0.117\frac{h}{t}$	$\frac{h}{t} = 173$	$\frac{3,500}{(h/t)}$	
				16 [⊙]	---	16 [⊙]	$\frac{h}{t} = 219^{\circ}$	$\frac{3,500}{(h/t)}$	
SHEAR IN WEBS, gross section		Unstiffened flat webs	20	12	$\frac{h}{t} = 36$	$15.6-0.099\frac{h}{t}$	$\frac{h}{t} = 65$	$\frac{39,000}{(h/t)^2}$	
				7.5 [⊙]	---	7.5 [⊙]	$\frac{h}{t} = 72^{\circ}$	$\frac{39,000}{(h/t)^2}$	
		Stiffened flat webs	21	12	---	12	$\frac{a_e}{t} = 66$	$\frac{53,000}{(a_e/t)^2}$	
				7.5 [⊙]	---	7.5 [⊙]	$\frac{a_e}{t} = 84^{\circ}$	$\frac{53,000}{(a_e/t)^2}$	

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

⊙ For all thicknesses with filler alloys 5356 or 5556. With filler alloys 4043 or 5554, values apply to metal $\frac{3}{8}$ in. or less in thickness; for greater thicknesses multiply allowable stresses by 0.8.

⊙ For all thicknesses with filler alloys 5356 or 5556; for metal $\frac{3}{8}$ in. or less in thickness with filler alloys 4043 or 5554.

Table 3.3.26
Allowable Stresses for
BUILDING and Similar
Type Structures
6063-T5
Extrusions, Pipe
(Thickness up thru
0.500 in.)

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section	Any tension member:	1	9.5	6.5
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	9.5	6.5
	Round or oval tubes	3	11.5	8.0
	Rectangular bars, plates, shapes bent about weak axis	4	12.5	8.5
BEARING	On rivets and bolts	5	16	13.5
	On flat surfaces and pins	6	10.5	9

Table 3.3.26
Allowable Stresses for BUILDING and Similar Type Structures
6063-T5
Extrusions, Pipe (Thickness up thru 0.500 in.)

			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	8.5 6.5	$\frac{L}{r} = 11$ $\frac{L}{r} = 65$	$8.9-0.037\frac{L}{r}$ $8.9-0.037\frac{L}{r}$	$\frac{L}{r} = 99$ $\frac{L}{r} = 99$	$\frac{51,000}{(L/r)^2}$ $\frac{51,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	8.5 6.5	$\frac{b}{t} = 6.8$ $\frac{b}{t} = 16$	$10.0-0.22\frac{b}{t}$ $10.0-0.22\frac{b}{t}$	$\frac{b}{t} = 18$ $\frac{b}{t} = 18$	$\frac{1,970}{(b/t)^2}$ $\frac{1,970}{(b/t)^2}$
	Flat plates with both edges supported	9	8.5 6.5	$\frac{b}{t} = 21$ ---	$10.0-0.071\frac{b}{t}$ 6.5	$\frac{b}{t} = 50$ $\frac{b}{t} = 49$	$\frac{320}{(b/t)}$ $\frac{320}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes	10	8.5 6.5	$\frac{R}{t} = 23$ $\frac{R}{t} = 10$	$9.8-0.27\sqrt{\frac{R}{t}}$ $7.2-0.22\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 270$ $\frac{R}{t} = 510$	$\frac{3,200}{(R/t)(1+\sqrt{R/t/35})^2}$ $\frac{3,200}{(R/t)(1+\sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	9.5 6.5	$\frac{L_b}{r_y} = 28$ $\frac{L_b}{r_y} = 111$	$10.5-0.036\frac{L_b}{r_y}$ $10.5-0.036\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 119$ $\frac{L_b}{r_y} = 119$	$\frac{87,000}{(L_b/r_y)^2}$ $\frac{87,000}{(L_b/r_y)^2}$
	Round or oval tubes	12	11.5 8	$\frac{R_b}{t} = 43$ $\frac{R_b}{t} = 62$	$17.5-0.92\sqrt{\frac{R_b}{t}}$ $12.8-0.61\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 140$ $\frac{R_b}{t} = 206$	Same as Specification No. 10 Same as Specification No. 10
	Solid rectangular beams	13	12.5 8.5	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 18$ $\frac{d}{t}\sqrt{\frac{L_b}{d}} = 33$	$17.2-0.26\frac{d}{t}\sqrt{\frac{L_b}{d}}$ $17.2-0.26\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 45$ $\frac{d}{t}\sqrt{\frac{L_b}{d}} = 45$	$\frac{11,400}{(d/t)^2(L_b/d)}$ $\frac{11,400}{(d/t)^2(L_b/d)}$
	Rectangular tubes and box sections	14	9.5 6.5	$\frac{L_b S_c}{I_y} = 204$ $\frac{L_b S_c}{I_y} = 3270$	$10.5-0.070\sqrt{\frac{L_b S_c}{I_y}}$ $10.5-0.070\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3830$ $\frac{L_b S_c}{I_y} = 3830$	$\frac{24,000}{(L_b S_c/I_y)}$ $\frac{24,000}{(L_b S_c/I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	9.5 6.5	$\frac{b}{t} = 8.5$ ---	$11.8-0.27\frac{b}{t}$ 6.5	$\frac{b}{t} = 16$ $\frac{b}{t} = 18$	$\frac{120}{(b/t)}$ $\frac{120}{(b/t)}$
	Flat plates with both edges supported	16	9.5 6.5	$\frac{b}{t} = 28$ ---	$11.8-0.083\frac{b}{t}$ 6.5	$\frac{b}{t} = 50$ $\frac{b}{t} = 58$	$\frac{380}{(b/t)}$ $\frac{380}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	12.5 8.5	$\frac{b}{t} = 12$ $\frac{b}{t} = 22$	$17.2-0.39\frac{b}{t}$ $17.2-0.39\frac{b}{t}$	$\frac{b}{t} = 29$ $\frac{b}{t} = 29$	$\frac{4,900}{(b/t)^2}$ $\frac{4,900}{(b/t)^2}$
	Flat plates with both edges supported	18	12.5 8.5	$\frac{h}{t} = 64$ ---	$17.2-0.074\frac{h}{t}$ 8.5	$\frac{h}{t} = 115$ $\frac{h}{t} = 116$	$\frac{990}{(h/t)}$ $\frac{990}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported	19	12.5 8.5	$\frac{h}{t} = 147$ ---	$17.2-0.032\frac{h}{t}$ 8.5	$\frac{h}{t} = 270$ $\frac{h}{t} = 270$	$\frac{2,300}{(h/t)}$ $\frac{2,300}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	5.5 3.9	$\frac{h}{t} = 44$ ---	$6.7-0.027\frac{h}{t}$ 3.9	$\frac{h}{t} = 99$ $\frac{h}{t} = 100$	$\frac{39,000}{(h/t)^2}$ $\frac{39,000}{(h/t)^2}$
	Stiffened flat webs	21	5.5 3.9	---	5.5 3.9	$\frac{a_e}{t} = 98$ $\frac{a_e}{t} = 117$	$\frac{53,000}{(a_e/t)^2}$ $\frac{53,000}{(a_e/t)^2}$

$$a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$$

WHITE BARS

apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS

apply within 1.0 in. of a weld.

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table 3.3.27 Allowable Stresses for BUILDING and Similar Type Structures 6063—T6 Extrusions, Pipe			
TENSION, axial, net section	Any tension member:	1	15	6.5				
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	15	6.5				
	Round or oval tubes	3	18	8.0				
	Rectangular bars, plates, shapes bent about weak axis	4	20	8.5				
BEARING	On rivets and bolts	5	24	13.5				
	On flat surfaces and pins	6	16	9.0				
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$	
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	13.5	$\frac{L}{r} = 9.5$	$14.2 - 0.074 \frac{L}{r}$	$\frac{L}{r} = 78$	$\frac{51,000}{(L/r)^2}$	
			6.5	---	6.5	$\frac{L}{r} = 89$	$\frac{51,000}{(L/r)^2}$	
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	13.5	$\frac{b}{t} = 5.7$	$16.1 - 0.46 \frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{1,970}{(b/t)^2}$	
			6.5	---	6.5	$\frac{b}{t} = 17$	$\frac{1,970}{(b/t)^2}$	
	Flat plates with both edges supported	9	13.5	$\frac{b}{t} = 18$	$16.1 - 0.144 \frac{b}{t}$	$\frac{b}{t} = 39$	$\frac{410}{(b/t)}$	
			6.5	---	6.5	$\frac{b}{t} = 63$	$\frac{410}{(b/t)}$	
	Curved plates supported on both edges, walls of round or oval tubes	10	13.5	$\frac{R}{t} = 18$	$15.6 - 0.50 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 188$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$	
			6.5	$\frac{R}{t} = 10$	$7.2 - 0.22 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 510$	$\frac{3,200}{(R/t)(1 + \sqrt{R/t/35})^2}$	
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	15	$\frac{L_b}{r_y} = 23$	$16.7 - 0.073 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 94$	$\frac{87,000}{(L_b/r_y)^2}$	
			6.5	---	6.5	$\frac{L_b}{r_y} = 116$	$\frac{87,000}{(L_b/r_y)^2}$	
	Round or oval tubes	12	18	$\frac{R_b}{t} = 33$	$27.7 - 1.70 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 102$	Same as Specification No. 10	
			8	$\frac{R_b}{t} = 62$	$12.8 - 0.61 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 206$	Same as Specification No. 10	
	Solid rectangular beams	13	20	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 15$	$27.9 - 0.53 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 35$	$\frac{11,400}{(d/t)^2 (L_b/d)}$	
			8.5	---	8.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 37$	$\frac{11,400}{(d/t)^2 (L_b/d)}$	
	Rectangular tubes and box sections	14	15	$\frac{L_b S_c}{I_y} = 145$	$16.7 - 0.141 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 2380$	$\frac{24,000}{(L_b S_c/I_y)}$	
			6.5	---	6.5	$\frac{L_b S_c}{I_y} = 3690$	$\frac{24,000}{(L_b S_c/I_y)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	15	$\frac{b}{t} = 7.4$	$19.0 - 0.54 \frac{b}{t}$	$\frac{b}{t} = 12$	$\frac{152}{(b/t)}$	
			6.5	---	6.5	$\frac{b}{t} = 23$	$\frac{152}{(b/t)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with both edges supported	16	15	$\frac{b}{t} = 24$	$19.0 - 0.170 \frac{b}{t}$	$\frac{b}{t} = 39$	$\frac{480}{(b/t)}$	
			6.5	---	6.5	$\frac{b}{t} = 74$	$\frac{480}{(b/t)}$	
	Flat plates with compression edge free, tension edge supported	17	20	$\frac{b}{t} = 9.8$	$27.9 - 0.81 \frac{b}{t}$	$\frac{b}{t} = 23$	$\frac{4,900}{(b/t)^2}$	
			8.5	---	8.5	$\frac{b}{t} = 24$	$\frac{4,900}{(b/t)^2}$	
	Flat plates with both edges supported	18	20	$\frac{h}{t} = 51$	$27.9 - 0.155 \frac{h}{t}$	$\frac{h}{t} = 90$	$\frac{1,260}{(h/t)}$	
			8.5	---	8.5	$\frac{h}{t} = 148$	$\frac{1,260}{(h/t)}$	
Flat plates with horizontal stiffener, both edges supported	19	20	$\frac{h}{t} = 118$	$27.9 - 0.067 \frac{h}{t}$	$\frac{h}{t} = 209$	$\frac{2,900}{(h/t)}$		
		8.5	---	8.5	$\frac{h}{t} = 340$	$\frac{2,900}{(h/t)}$		
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	8.5	$\frac{h}{t} = 39$	$10.7 - 0.056 \frac{h}{t}$	$\frac{h}{t} = 78$	$\frac{39,000}{(h/t)^2}$	
			3.9	---	3.9	$\frac{h}{t} = 100$	$\frac{39,000}{(h/t)^2}$	
	Stiffened flat webs	21	8.5	---	8.5	$\frac{a_c}{t} = 79$	$\frac{53,000}{(a_c/t)^2}$	
3.9			---	3.9	$\frac{a_c}{t} = 117$	$\frac{53,000}{(a_c/t)^2}$		

tension, bearing/allowable stresses

3.4 Allowable Stresses. Allowable stresses for aluminum alloy members shall be determined in accordance with formulas listed in Table 3.3.6. Allowable stresses in building and similar type structures are given in Tables 3.3.7 to 3.3.27 for some commonly used alloys.

The following explanations correspond with these formulas. When two formulas are given, the smaller of the resulting stresses should be used.

3.4.1 Tension, Axial, Net Section.

$$F = F_{ty}/n_y \quad \text{or} \quad F = F_{tu}/(k_t n_u)$$

3.4.2 Tension in Extreme Fibers of Beams—Rectangular Tubes, Structural Shapes Bent About Strong Axis.

$$F = F_{ty}/n_y \quad \text{or} \quad F = F_{tu}/(k_t n_u)$$

3.4.3 Tension in Extreme Fibers of Beams—Round or Oval Tubes.

$$F = 1.17 F_{ty}/n_y \quad \text{or} \quad F = 1.24 F_{tu}/(k_t n_u)$$

The allowable tensile stress for round or oval tubes subjected to bending is somewhat higher than for structural shapes. Analysis and tests have demonstrated that yielding or failure of tubular beams does not occur until the bending moment considerably exceeds the value predicted by the ordinary flexure formula. The constants of 1.17 and 1.24 were developed on this basis. The factor k_t provides an additional factor of safety on tensile strength for some alloys that do not develop sufficiently high tensile properties in the presence of stress concentrations. Applicable values for k_t are listed in Table 3.3.5.

3.4.4 Tension in Extreme Fibers of Beams—Rectangular Bars, Plates, Shapes Bent About Weak Axis.

$$F = 1.30 F_{ty}/n_y \quad \text{or} \quad F = 1.42 F_{tu}/(k_t n_u)$$

As in the case of round tubes, theory and tests have shown that aluminum alloy members of these shapes can undergo bending moments that are considerably higher than those predicted on the basis of the ordinary flexure formula. k_t values are listed in Table 3.3.5.

3.4.5 Bearing on Rivets and Bolts.

$$F = F_{by}/n_y \quad \text{or} \quad F = F_{bu}/(1.2 n_u)$$

This value shall be used for a ratio of edge distance to fastener diameter of 2 or greater. For smaller ratios this allowable stress shall be multiplied by the ratio: (edge distance)/(2 × fastener diameter). Edge distance is the distance from the center of the fastener to the edge of the material in the direction of the applied load.

3.4.6 Bearing on Flat Surfaces and Pins.

$$F = F_{by}/(1.5 n_y) \quad \text{or} \quad F = F_{bu}/(1.8 n_u)$$

This allowable stress is equal to two-thirds of the allowable bearing stress on fasteners.

3.4.7 Compression in Columns, Axial, Gross Section.

$$(a) F_c = \frac{F_{cy}}{k_c n_y}$$

For L/r below slenderness limit S_1 .

This value of F_c is the basic allowable compressive design stress. Values of k_c can be determined from Table 3.3.5. The quantity k_c adjusts the factor of safety on compressive yield strength in order to provide a range of slenderness ratios in the short column range for which the allowable stress is independent of the slenderness ratio.

$$(b) F_c = \frac{1}{n_u} \left(B_c - D_c \frac{L}{r} \right)$$

For L/r between S_1 and S_2 .

$$(c) F_c = \frac{\pi^2 E}{n_u (L/r)^2}$$

For L/r above S_2 .

In Formulas (b) and (c), the factor of safety n_u is applied to the calculated strength of pinned-ended columns. The use of n_u and the neglect of end restraint compensate for the possible weakening effects of accidental eccentricity and crookedness in columns.

3.4.8 Compression in Components of Columns—Outstanding Flanges and Legs.

$$(a) F_c = \frac{F_{cy}}{k_c n_y}$$

For b/t below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_u} \left(B_p - 5.1 D_p \frac{b}{t} \right)$$

For b/t between S_1 and S_2 .

$$(c) F_c = \frac{\pi^2 E}{n_u (5.1 b/t)^2}$$

For b/t values above S_2 .

It is assumed that the strength of columns with outstanding flanges or legs will be limited by the local buckling strength of the legs. No allowance is made for postbuckling strength in such members. Note that the formulas (b) and (c) above are in the same form as the formulas of 3.4.7 (b) and (c). In formulas 3.4.8 (b) and (c), the equivalent slenderness ratio for plate buckling is assumed to be $5.1 b/t$, where the coefficient 5.1 is the value that applies to a plate free on one edge and simply supported on the other. Open section members that are unsymmetrical about one or both principal axes may be subject to failure by combined torsion and flexure. For single or double angles and tee sections an adequate factor of safety against this type of failure is provided. Other unsymmetrical, open shapes, such as channels, lipped angles or hat shapes should not be used as columns unless a special analysis is made of the resistance to buckling by combined torsion and flexure.

allowable stresses/compression

3.4.9 Compression in Components of Columns, Gross Section—Flat Plates With Both Edges Supported.

$$(a) F_c = \frac{F_{cy}}{k_c n_y}$$

For b/t less than slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_u} \left(B_p - 1.6 D_p \frac{b}{t} \right)$$

For b/t between S_1 and S_2 .

The equivalent slenderness ratio is considered to be $1.6 b/t$, the value that applies to a plate simply supported on both longitudinal edges. In this range of b/t values, the local buckling strength is essentially the same as the ultimate or "crippling" strength.

$$(c) F_c = \frac{k_2 \sqrt{B_p E}}{n_u (1.6 b/t)}$$

For b/t greater than S_2 .

Values of k_2 , and also k_1 which appears in the expression for S_2 , are given in Tables 3.3.4a and 3.3.4b. This formula is based on the crippling strength of a plate simply supported on both longitudinal edges. This strength may be appreciably greater than the local buckling strength for thin sections. See Section 4.7.

3.4.10 Compression in Components of Columns, Gross Section—Curved Plates Supported on Both Edges, Walls of Round or Oval Tubes.

$$(a) F_c = \frac{F_{cy}}{k_c n_y}$$

For R/t below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_u} (B_t - D_t \sqrt{R/t})$$

For R/t between S_1 and S_2 .

$$(c) F_c = \frac{\pi^2 E}{16 n_u \left(\frac{R}{t} \right) \left[1 + \frac{\sqrt{R/t}}{35} \right]^2}$$

For R/t greater than S_2 .

Formulas (b) and (c) are based on the local buckling strength of tubes in direct compression.

3.4.11 Compression in Beams, Extreme Fiber, Gross Section—Single Web Beams Bent About Strong Axis.

$$(a) F_c = \frac{F_{cy}}{n_y}$$

For L_b/r_y below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_y} \left(B_c - \frac{D_c L_b}{1.2 r_y} \right)$$

For L_b/r_y between S_1 and S_2 .

The allowable compressive stresses in single web structural shapes and built-up sections bent about the strong axis are based on the lateral, torsional buckling strength of beams with the appropriate factor of safety applied. Allowable stresses in the inelastic stress range for beams are based on the straight line approximation to the tangent modulus buckling curve that is also used for columns. In deriving the allowable stresses for beams, it was assumed that the beam is held in an upright position at the supported ends. The strengthening effect of any restraint against rotation of the flanges at the supports was neglected. The factor of safety on yielding, n_y , is applied to the calculated buckling strength of beams, since experience has indicated this practice to be conservative.

$$(c) F_c = \frac{\pi^2 E}{n_y (L_b/1.2 r_y)^2}$$

For L_b/r_y greater than S_2 .

This is based on a conservative approximation to the elastic buckling strength of beams, with L_b/r_y replacing a more complicated function of the length and cross section properties. See Section 4.9.

3.4.12 Compression in Beams, Extreme Fiber, Gross Section—Round or Oval Tubes.

$$(a) F_c = \frac{1.17 F_{cy}}{n_y}$$

For R_b/t below slenderness limit S_1 .

This allowable stress is increased over the basic allowable compressive design stress for single web beams owing to the fact that tests have demonstrated a shape factor of 1.17 for yielding of round and oval tubes.

$$(b) F_c = \frac{1}{n_y} \left[B_{tb} - D_{tb} \sqrt{\frac{R_b}{t}} \right]$$

For R_b/t between S_1 and S_2 .

(c) For R_b/t values greater than S_2 , the allowable bending stress shall be determined from the formulas for tubes in compression in Section 3.4.10 using the formula that is appropriate for the particular value of R_b/t . Note that in this case R_b/t may be either less than or greater than the value of S_2 for tubes in compression.

3.4.13 Compression in Beams, Extreme Fiber, Gross Section—Solid Rectangular Beams.

$$(a) F_c = \frac{1.30 F_{cy}}{n_y}$$

For $\frac{d}{t} \sqrt{\frac{L_b}{d}}$ below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_y} \left[B_b - 2.3 D_b \frac{d}{t} \sqrt{\frac{L_b}{d}} \right]$$

For $\frac{d}{t} \sqrt{\frac{L_b}{d}}$ between S_1 and S_2 .

$$(c) F_c = \frac{\pi^2 E}{5.29 n_y (d/t)^2 (L_b/d)}$$

For $\frac{d}{t} \sqrt{\frac{L_b}{d}}$ values greater than S_2 .

The above formulas for allowable stresses in rectangular beams are based on the lateral, torsional buckling strength of such beams.

3.4.14 Compression in Beams, Extreme Fiber, Gross Section—Rectangular Tubes and Box Sections.

$$(a) F_c = \frac{F_{cy}}{n_y}$$

For $\frac{L_b S_c}{I_y}$ below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_y} \left[B_c - 1.6 D_c \sqrt{\frac{L_b S_c}{I_y}} \right]$$

For $\frac{L_b S_c}{I_y}$ between S_1 and S_2 .

$$(c) F_c = \frac{\pi^2 E}{2.56 n_y \left(\frac{L_b S_c}{I_y} \right)}$$

For $\frac{L_b S_c}{I_y}$ greater than S_2 .

The above formulas for allowable stresses in box beams are based on the lateral, torsional buckling strength of such beams. In deriving these formulas, use was made of the fact that lateral buckling will govern the design only for relatively deep, narrow box beams and for these members the torsion constant J is roughly proportional to I_y .

3.4.15 Compression in Components of Beams (Component Under Uniform Compression), Gross Section—Outstanding Flanges.

$$(a) F_c = \frac{F_{cy}}{n_y}$$

For b/t below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_y} \left[B_p - 5.1 D_p \left(\frac{b}{t} \right) \right]$$

For b/t between S_1 and S_2 .

$$(c) F_c = \frac{k_2 \sqrt{B_p E}}{n_y (5.1 b/t)}$$

For b/t greater than S_2 .

Values of k_2 , and also k_1 which appears in the expression for S_2 , are given in Tables 3.3.4a and 3.3.4b. Formulas (b) and (c) are based on the crippling strength of an outstanding flange simply supported on one edge. See Section 4.7.

3.4.16 Compression in Components of Beams (Component Under Uniform Compression), Gross Section—Flat Plates With Both Edges Supported.

$$(a) F_c = \frac{F_{cy}}{n_y}$$

For b/t below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_y} \left[B_p - 1.6 D_p \left(\frac{b}{t} \right) \right]$$

For b/t between S_1 and S_2 .

$$(c) F_c = \frac{k_2 \sqrt{B_p E}}{n_y (1.6 b/t)}$$

For b/t greater than S_2 .

Values of k_1 and k_2 are given in Tables 3.3.4a and 3.3.4b. Formulas (b) and (c) are based on the crippling strength of a plate simply supported on both edges. See Section 4.7.

3.4.17 Compression in Components of Beams (Component Under Bending in Own Plane), Gross Section—Flat Plates With Compression Edge Free, Tension Edge Supported.

$$(a) F_c = \frac{1.3 F_{cy}}{n_y}$$

For b/t below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_y} \left[B_b - 3.5 D_b \left(\frac{b}{t} \right) \right]$$

For b/t between S_1 and S_2 .

The coefficients in the formula for inelastic buckling strength were assumed to be the same as for rectangular beams because calculations and tests have shown that the apparent stress (M_c/I) at which the yield strength is reached in the outer fiber of sections such as tees, angles and channels is even higher than for rectangular beams. The equivalent slenderness ratio was assumed to be $3.5 b/t$, which implies partial restraint against rotation at the supported edge.

$$(c) F_c = \frac{\pi^2 E}{n_y (3.5 b/t)^2}$$

For b/t greater than S_2 .

This is based on elastic buckling strength. This type of component is assumed to have negligible postbuckling strength.

allowable stresses/compression, shear

3.4.18 Compression in Components of Beams (Component Under Bending in Own Plane), Gross Section – Flat Plates With Both Edges Supported.

$$(a) F_c = \frac{1.3 F_{cy}}{n_y}$$

For h/t below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_y} \left[B_b - 0.67 D_b \left(\frac{h}{t} \right) \right]$$

For h/t between S_1 and S_2 .

The equivalent slenderness ratio used in this formula is $0.67 h/t$, which applies to a plate in bending, simply supported on both edges.

$$(c) F_c = \frac{k_2 \sqrt{B_b E}}{n_y (0.67 h/t)}$$

For h/t greater than S_2 .

Values of k_1 and k_2 are given in Tables 3.3.4a and 3.3.4b. This formula is based on crippling strength. See Section 4.7.

3.4.19 Compression in Components of Beams (Component Under Bending in Own Plane), Gross Section – Flat Plates With Horizontal Stiffener, Both Edges Supported.

$$(a) F_c = \frac{1.3 F_{cy}}{n_y}$$

For h/t below slenderness limit S_1 .

$$(b) F_c = \frac{1}{n_y} \left[B_b - 0.29 D_b \left(\frac{h}{t} \right) \right]$$

For h/t between S_1 and S_2 .

The equivalent slenderness ratio in this formula is $0.29 h/t$, based on simple support at the edges and at the stiffener.

$$(c) F_c = \frac{k_2 \sqrt{B_b E}}{n_y (0.29 h/t)}$$

For h/t between S_1 and S_2 .

Values of k_1 and k_2 are given in Tables 3.3.4a and 3.3.4b. This formula is based on crippling strength. See Section 4.7.

3.4.20 Shear in Webs – Unstiffened Flat Webs.

$$(a) F_s = \frac{F_{sy}}{n_y}$$

For h/t below slenderness limit S_1 .

$$(b) F_s = \frac{1}{n_y} \left[B_s - 1.25 D_s \left(\frac{h}{t} \right) \right]$$

For h/t between S_1 and S_2 .

$$(c) F_s = \frac{\pi^2 E}{n_y (1.25 h/t)^2}$$

For h/t greater than S_2 .

Allowable shear stresses in unstiffened flat webs are determined by applying the basic factor of safety to the calculated buckling strength for a web with partial restraint against rotation at the attachment to the flanges. The corresponding value of the equivalent slenderness ratio is $1.25 h/t$.

3.4.21 Shear in Webs – Stiffened Flat Webs.

$$(a) F_s = \frac{F_{sy}}{n_y}$$

For a_e/t below slenderness limit S_1 ,

where:

$$a_e = \frac{a_1}{\sqrt{1 + 0.7 (a_1/a_2)^2}}$$

$$(b) F_s = \frac{1}{n_a} \left[B_s - 1.25 D_s \left(\frac{a_e}{t} \right) \right]$$

For a_e/t between S_1 and S_2 .

$$(c) F_s = \frac{\pi^2 E}{n_a (1.25 a_e/t)^2}$$

For a_e/t greater than S_2 .

Allowable stresses for stiffened flat webs are determined on the basis of assumptions similar to those used for unstiffened webs except that a factor of safety ($n_a = 1.2$ for building structures) is applied to the buckling strength of stiffened beam webs. Tests have demonstrated that shear stresses in such webs can considerably exceed the calculated buckling strength without appreciably affecting the behavior of the beam.

Section 4. Special Design Rules

4.1 Combined Compression and Bending. A member subjected to axial compression and carrying a bending moment due to lateral or eccentric loads shall be proportioned in accordance with the following formulas:

4.1.1 Bending Moment at Center Equal to or Greater than 0.9 of Maximum Bending Moment in Span:

$$\frac{f_a}{F_a} + \frac{f_b}{F_b (1 - f_a/F_{ec})} \leq 1$$

where:

f_a = average compressive stress on cross-section produced by axial compressive load

F_a = allowable compressive stress for member considered as an axially loaded column

f_b = maximum bending stress (compression) caused by transverse loads or end moments

F_b = allowable compressive stress for member considered as a beam

$$F_{ec} = \pi^2 E / [n_u (L/r)^2]$$

4.1.2 Bending Moment at Center Equal to or Less than 0.5 of Maximum Bending Moment in Span:

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \leq 1$$

4.1.3 Bending Moment at Center Between 0.5 and 0.9 of Maximum Bending Moment in Span:

$$\frac{f_a}{F_a} + \frac{f_b}{F_b \left[1 - \left(\frac{2M_c}{M_m} - 1 \right) \frac{f_a}{F_{ec}} \right]} \leq 1$$

where:

M_c = bending moment at center of span.

M_m = maximum bending moment in span.

4.2 Torsion and Shear in Tubes. Allowable shear stresses in round or oval tubes due to torsion or transverse shear loads shall be determined from Section 3.4.20 (Specification 20 in Tables 3.3.6 to 3.3.27) with the ratio h/t replaced by an equivalent h/t given by the following:

$$\text{Equivalent } \frac{h}{t} = 2.9 \left(\frac{R}{t} \right)^{5/8} \left(\frac{L_t}{R} \right)^{1/4}$$

where:

R = outside radius of round tube or maximum outside radius of oval tube, in.

t = thickness of tube, in.

L_t = length of tube between circumferential stiffeners, in.

Equivalent (h/t) = value to be substituted for h/t in Section 3.4.20 (Specification 20 in Tables 3.3.6 to 3.3.27).

4.3 Combined Shear, Compression and Bending. Allowable combinations of shear, compression and bending, as in the web of a beam column or the wall of a tube, shall be determined from the following formula:

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} + \left(\frac{f_s}{F_s} \right)^2 \leq 1.0$$

where:

f_a = average compressive stress produced by axial compressive load, ksi

F_a = allowable compressive stress for member subjected to compression only, ksi

f_b = maximum bending stress (compression) produced by applied bending moment, ksi

F_b = allowable bending stress (compression) for members subjected to bending only, ksi

f_s = shear stress caused by torsion or transverse shear loads, ksi

F_s = allowable shear stress for member subjected only to torsion or shear, ksi

4.4 Stiffeners for Outstanding Flanges. Outstanding flanges stiffened by lips or bulbs at the free edge shall be considered as supported on both edges if the radius of gyration of the lip or bulb meets the following requirement:

$$r_L = \frac{b}{5}$$

where

r_L = radius of gyration of lip or bulb about the midthickness of the flange from which lip projects, in.

b = clear width of flange, in.

For simple rectangular lips having the same thickness as the flange, as in the case of formed sheet construction, the preceding requirement can be expressed as:

$$b_L = b/3$$

where:

b_L = clear width of lip, in.

Allowable stresses for flanges with lips or bulbs meeting the foregoing requirements shall be determined from Sections 3.4.15 and 3.4.16 (Specifications 15 and 16 in Tables 3.3.6 to 3.3.27). The area of stiffening lips or bulbs may be included with the area of the rest of the section in calculating the stresses caused by the loads.

4.5 Horizontal Stiffeners for Shear Webs. If a horizontal stiffener is used on a beam web, it shall be located so that the distance from the toe of the compression flange to the centroid of the stiffener is 0.4 of the distance from the toe of the compression flange to the toe of the tension flange. The horizontal stiffener shall have a moment of inertia, about the web of the beam, not less than that given by the expression:

$$I_h = 2\alpha f t h^3 \left[\left(1 + \frac{6A_h}{ht} \right) \left(\frac{s}{h} \right)^2 + 0.4 \right] 10^{-6}$$

where:

I_h = moment of inertia of the horizontal stiffener about the web of the beam, in.⁴

$\alpha = 1$, for stiffener consisting of equal members on both sides of the web

$\alpha = 3.5$, for stiffener consisting of member on only one side of web

h = clear height of web between flanges, in.

t = thickness of web, in.

f = compressive stress at toe of flange, ksi

s = distance between vertical stiffeners, in.

A_h = gross area of cross section of horizontal stiffener, in.²

For a stiffener consisting of equal members on both sides of the web, the moment of inertia I_h shall be the sum of the moments of inertia about the centerline of the web. For a stiffener consisting of a member on one side only, the moment of inertia shall be taken about the face of the web in contact with the stiffener.

4.6 Vertical Stiffeners for Shear Webs. Stiffeners applied to beam webs to resist shear buckling shall have a moment of inertia not less than the value given by the following expression:

$$\frac{s}{h} \leq 0.4, \quad I_s = \frac{n_a V h^2}{22,400} \left(\frac{s}{h} \right)$$

$$\frac{s}{h} \geq 0.4, \quad I_s = \frac{n_a V h^2}{140,000} \left(\frac{h}{s} \right)$$

special design rules/thin sections

where:

- I_s = moment of inertia of stiffener, in.⁴
- V = shear force on web at stiffener location, kips
- h = clear height of web, in.
- s = stiffener spacing, in.
- n_a = factor of safety on appearance of buckling, equal to 1.2

When a stiffener is composed of a pair of members, one on each side of the web, the stiffener spacing s shall be the clear distance between the pairs of stiffeners. When a stiffener is composed of a member on one side only of the web, the stiffener spacing s shall be the distance between rivet lines or other connecting lines.

For a stiffener composed of members of equal size on each side of the web, the moment of inertia of the stiffener shall be computed about the centerline of the web. For a stiffener composed of a member on one side only of the web, the moment of inertia of the stiffener shall be computed about the face of the web in contact with the stiffener.

In the determination of the required moment of inertia of stiffeners, the distance h shall always be taken as the full clear height of the web regardless of whether or not a horizontal stiffener is present.

Stiffeners shall extend from flange to flange but need not be connected to either flange.

Unless the outer edge of a stiffener is continuously stiffened, its thickness shall not be less than $1/12$ th the clear width of the outstanding leg.

Vertical stiffeners shall, where possible, be placed in pairs at end bearings and at points of support of concentrated loads. They shall be connected to the web by enough rivets, or other means, to transmit the load. Such stiffeners shall be fitted to form a tight and uniform bearing against the loaded flanges, unless welds, designed to transmit the full reaction or load, are provided between flange and stiffener.

Only that part of a stiffener cross section which lies outside the fillet of the flange angle shall be considered as effective in bearing. Bearing stiffeners shall not be jogged.

The moment of inertia of the bearing stiffener shall not be less than that given by the following expression:

$$I_b = I_s + \frac{Ph^2 n_u}{\pi^2 E}$$

where:

- I_b = required moment of inertia of bearing stiffener, in.⁴
- I_s = moment of inertia required to resist shear buckling, in.⁴
- P = local load concentration on stiffener, kips
- h = clear height of web between flanges, in.
- n_u = factor of safety
- E = compressive modulus of elasticity, ksi

4.7 Special Provisions For Thin Sections. All the allowable stresses listed in these specifications apply

to either thin or heavy gage construction. In some cases, however, special consideration should be given to the design of thin gage sections, as indicated in the following paragraphs.

4.7.1 Appearance of Buckling. For very thin sections the allowable compressive stresses given in Sections 3.4.9, 3.4.15, 3.4.16, 3.4.18, and 3.4.19 (Specifications 9, 15, 16, 18 and 19 of Tables 3.3.6 to 3.3.27) may result in visible local buckling, even though an adequate margin of safety is provided against ultimate failure. In applications where any appearance of buckling must be avoided, the allowable stresses for thin sections shall not exceed the value of F_{ab} given by the following formulas:

Section	Allowable Stress, F_{ab} , ksi
3.4.9, 3.4.16	$F_{ab} = \frac{\pi^2 E}{n_a (1.6b/t)^2}$
3.4.15	$F_{ab} = \frac{\pi^2 E}{n_a (5.1b/t)^2}$
3.4.18	$F_{ab} = \frac{\pi^2 E}{n_a (0.67h/t)^2}$
3.4.19	$F_{ab} = \frac{\pi^2 E}{n_a (0.29h/t)^2}$

4.7.2 Weighted Average Allowable Compressive Stress.

The cross section of a compression member may be composed of several thin elements, for which allowable stresses are given by Sections 3.4.8, 3.4.9, or 3.4.10. The allowable compressive stress for the section as a whole may be considered to be the weighted average allowable stress for the individual elements, where the allowable stress for each element is weighted in accordance with the ratio of the area of the element to the total area of the section. The allowable compressive stress for the section as a whole used as a column must not exceed that given by Section 3.4.7. (Specification 7 of Tables 3.3.6 to 3.3.27).

Weighted average allowable compressive stresses for beam flanges may be calculated in the same way, where the allowable stresses for individual elements are determined from Sections 3.4.15 through 3.4.19 (Specifications 15 through 19 of Tables 3.3.6 to 3.3.27). The beam flange may be considered to consist of the flange proper plus one sixth of the area of the web or webs.

4.7.3 Trapezoidal Formed Sheet Beams. The weighted average allowable compressive stress for a trapezoidal formed sheet beam, calculated according to Section 4.7.2, is:

$$F_{ba} = \frac{F_{bf} + F_{bh} \left(\frac{h}{3b} \right)}{1 + \frac{h}{3b}}$$

where:

F_{ba} = weighted average allowable compressive stress for beam flange, ksi

F_{bf} = allowable stress for flange proper based on Section 3.4.16 (Specification 16 of Tables 3.3.6 to 3.3.27), ksi

F_{bh} = allowable stress for webs based on Sections 3.4.18 or 3.4.19 (Specification 18 or 19 of Tables 3.3.6 to 3.3.27), ksi

h = height of shear web, in. (see sketch, Specification no. 18, Table 3.3.6).

b = clear width of compression flange, in.

The foregoing equation may also be applied to the allowable tensile stress in trapezoidal formed sheet beams, if the designer wishes to take full advantage of the strength of the section. In this case, F_{ba} is the weighted average allowable tensile stress, F_{bf} is determined from Section 3.4.2 (Specification 2 in Tables 3.3.6 to 3.3.27) and F_{bh} is given by Section 3.4.4 (Specification 4 in Tables 3.3.6 to 3.3.27).

For trapezoidal formed sheet beams with tension flanges wider than the compression flange, the allowable tensile stress on the tension flange shall not exceed the compressive stress that would be allowed if the same flange were in compression. This provision is required to take account of the effects of "flange curling", the tendency of the tension flange to bend toward the neutral axis.

4.7.4 Effect of Local Buckling on Column Strength. An additional limitation must be placed on the allowable stress for very thin walled columns whose cross section is a rectangular tube or a formed sheet shape such that the flanges consist of flat elements supported on both edges. If the b/t for the flange of such a column is less than the value of S_2 in Section 3.4.9 (Specification 9 of Tables 3.3.6 to 3.3.27) or is less than 0.6 of the maximum slenderness ratio (L/r) for the column, no additional reduction in allowable stress is necessary. However, if the maximum b/t for the flange is greater than the value of S_2 from Section 3.4.9 (Specification 9 of Tables 3.3.6 to 3.3.27) and also greater than 0.6 of the maximum slenderness ratio for the column, the allowable column stress shall not exceed the value given by

$$F_{rc} = \frac{\pi^2 E}{n_u (L/r)^{2/3} (1.6b/t)^{4/3}}$$

where:

F_{rc} = reduced allowable stress on column, ksi

L/r = maximum slenderness ratio of column

b/t = width to thickness ratio for column flange

E = compressive modulus of elasticity, ksi

n_u = factor of safety on ultimate strength (1.95 for building structures).

The allowable stress shall also not exceed the value given by Section 3.4.9 (Specification 9 of Tables 3.3.6 to 3.3.27).

Section 3.4.9 takes advantage of the postbuckling strength of plate elements supported on two edges, because in general such elements may buckle without causing failure of the member. However, there are cases where the reduced stiffness that accompanies local buckling of these elements may necessitate a reduction in the allowable column stress determined from Section 3.4.7, as provided in the foregoing paragraph. Sections 3.4.8 and 3.4.10 do not take advantage of postbuckling strength, so no provision is needed for any additional effect of local buckling of the types of elements covered by Sections 3.4.8 and 3.4.10.

4.7.5 Effect of Local Buckling on Beam Strength. The allowable compressive bending stress for single web beams whose flanges consist of thin, flat elements supported on one edge shall also be reduced in the case where the value of b/t for the flange is greater than the value of S_2 from Section 3.4.15 (Specification 15 of Tables 3.3.6 to 3.3.27) and also greater than 0.16 (L_b/r_y). In this case, the allowable beam stress shall not exceed

$$F_{rb} = \frac{\pi^2 E}{n_y (L_b/1.2r_y)^{2/3} (5.1b/t)^{4/3}}$$

where:

F_{rb} = reduced allowable compressive bending stress in beam flange, ksi

L_b/r_y = slenderness ratio for beam

b/t = width to thickness ratio for beam flange

E = compressive modulus of elasticity, ksi

n_y = factor of safety on yielding (1.65 for building structures).

Section 3.4.15 takes advantage of postbuckling strength of thin elements, just as Section 3.4.9 does for columns. The provisions of the foregoing paragraph take account of the effect that the reduced stiffness due to local buckling may have on the lateral buckling strength of single web beams. Any such effects on multiweb beams are considered to be negligible because of the high torsional stiffness of these members.

4.7.6 Effective Width for Calculation of Deflection of Thin Gage Sections. As noted in Section 4.7.1 the allowable compressive stresses given in Sections 3.4.9, 3.4.15, 3.4.16, 3.4.18 and 3.4.19 (Specifications 9, 15, 16, 18, and 19 of Tables 3.3.6 to 3.3.27) may result in some local buckling at design loads for very thin sections, even though an adequate margin of safety is provided against ultimate failure. This local buckling may result in increased deflections for sections containing thin elements with b/t values exceeding $1.65 S_2$, where the value of S_2 is obtained for the element in question from Sections 3.4.9, 3.4.15, 3.4.16, 3.4.18, or 3.4.19. (Specifications 9, 15, 16, 18, or 19 of Tables 3.3.6 to 3.3.27).

Where deflection at design loads is critical, the effective width concept may be used to determine an

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effective section to be used in deflection calculations. The effective width, b_e , of a thin element subjected to direct compression stresses is:

$$\text{If } f_a \leq n_a F_{ab}, \quad b_e = b$$

$$\text{If } f_a > n_a F_{ab}, \quad b_e = b \sqrt{n_a F_{ab} / f_a}$$

where:

b_e = effective width of flat plate element to be used in deflection calculations, in.

b = clear width of element, in.

n_a = factor of safety on appearance of buckling

F_{ab} = allowable stress for element from Section 4.7.1, ksi

f_a = compressive stress on element due to applied loads, ksi

The same expression may be used to calculate the effective width on the compression side of a web in bending, with the compressive bending stress due to the applied loads, f_b , replacing f_a .

4.8 Fatigue. For up to 100,000 repetitions of maximum live load, if non-welded, and 20,000 repetitions of maximum live load if welded, allowable stresses shall be determined in accordance with Sections 3 and 4 provided that the structural members are free of re-entrant corners and other unusual stress raisers. For repetitions of loads in excess of these values allowable stresses shall be determined by a special analysis.

20,000 repetitions of maximum live load represent 10 loading cycles every day for over 5 years. 100,000 repetitions of maximum live load represent 50 loading cycles every day for over 5 years or 10 loading cycles every day for over 27 years.

The maximum design loading rarely occurs in the life of a structure. Where, however, a structural member is subject to a very large number of fluctuations or reversals the possibility of its failure arises at a stress, usually tensile, lower than that permissible for static loading. Fatigue cracks may originate at a point of high stress, such as a re-entrant corner or a weld bead.

To design against fatigue calls for good practice based upon experience and testing. Careful detailing and fabrication are important. Whenever possible, prototype testing under the variable load patterns expected to occur in service should be conducted or expert advice based on relevant research should be sought.

Further information on allowable stresses for repeated loads for some alloys is given in ASCE Structural Division Proceedings Papers 3341 and 3342.

4.9 Compression in Single Web Beams. The formulas of Section 3.4.11 (Specification 11 of Tables 3.3.6–3.3.27) for single-web beams and girders are based on an approximation in which the term L_b/r_y replaces a

more complicated expression involving several different properties of the beam cross section. Because of this approximation, the formulas give very conservative results for certain conditions, namely for values of L_b/r_y exceeding about 50; for load distributions such that the bending moment near the center of the beam is appreciably less than the maximum bending moment in the beam; and for beams with transverse loads applied to the bottom flange. If the designer wishes to compute more precise values of allowable compressive stress for these cases, the value of r_y in Section 3.4.11 (Specification 11 of Tables 3.3.6–3.3.27) may be replaced by an “effective r_y ” given by one of the following formulas:

Beam spans subjected to end moment only or to transverse loads applied at the neutral axis of the beam:

$$\text{Effective } r_y = \frac{k_b}{1.7} \sqrt{\frac{I_y d}{S_c}} \sqrt{1 + 0.152 \frac{J}{I_y} \left(\frac{L_b}{d}\right)^2}$$

Beams subjected to transverse loads applied on the top or bottom flange (where the load is free to move laterally with the beam if the beam should buckle):

$$\text{Effective } r_y =$$

$$\frac{k_b}{1.7} \sqrt{\frac{I_y d}{S_c}} \left[\pm 0.5 + \sqrt{1.25 + 0.152 \frac{J}{I_y} \left(\frac{L_b}{d}\right)^2} \right]$$

The plus sign in front of the term “0.5” applies if the load is on the bottom flange; the minus sign if the load is on the top flange.

The terms appearing in the above formulas are defined as follows:

Effective r_y = value to be substituted for r_y in Section 3.3.11 (Specification 11 of Tables 3.3.6–3.3.27).

I_y = moment of inertia of beam about axis parallel to web, in.⁴

S_c = section modulus of beam, compression side, in.³

J = torsion constant of beam, in.⁴ (An approximate value of J may be calculated by assuming the section to be composed of rectangles and letting J equal the sum of the terms $bt^3/3$ for each rectangle.)

L_b = length of beam between points at which the compression flange is supported against lateral movement, or length of cantilever beam from free end to point at which the compression flange is supported against lateral movement, in.

Values of the coefficient k_b are tabulated on the following page.

<i>Beams Restrained Against Lateral Displacement at Both Ends of Span</i>	Value of Coefficient k_b
Uniform bending moment, uniform transverse load, or two equal concentrated loads equidistant from the center of the span.....	1.00
Bending moment varying uniformly from a value of M_1 at one end to M_2 at the other end	
$M_1/M_2 = 0.5$	1.14
$M_1/M_2 = 0$	1.33
$M_1/M_2 = -0.5$	1.53
$M_1/M_2 = -1.0$	1.60
Concentrated load at center of span.....	1.16
<i>Cantilever Beams</i>	
Concentrated load at end of span.....	1.13
Uniform transverse load.....	1.43

Section 5. Mechanical Connections

5.1 Riveted and Bolted Connections. Aluminum alloys used for rivets and bolts shall be those listed in Table 5.1.1b. Nuts for 1/4" bolts and smaller shall be 2024-T4. Nuts for larger diameter bolts shall be alloy 6061-T6 or 6262-T9. Flat washers shall be Alclad 2024-T4. Spring lock washers shall be alloy 7075-T6. For improved corrosion resistance, an .0002 inch minimum thickness anodic coating may be applied to alloy 2024 bolts.

5.1.1 Allowable Loads. The allowable loads on rivets and bolts shall be calculated using the allowable bearing stresses in Table 5.1.1a and the allowable shear stresses in Table 5.1.1b. The allowable bearing stress depends on the ratio of edge distance to rivet or bolt diameter where the edge distance is the distance from the center of the rivet or bolt to the edge of the load carrying member toward which the pressure of the rivet or bolt is directed (See Section 3.4.5). Allowable bearing stresses on bolts apply to either threaded or unthreaded surfaces.

5.1.2 Effective Diameter. The effective diameter of rivets shall be taken as the hole diameter, but shall not exceed the nominal diameter of the rivet by 4% for cold driven rivets and 7% for hot driven rivets. The effective diameter of bolts shall be taken as the nominal diameter of the bolt.

5.1.3 Shear Area. The effective area of a rivet or bolt in any shear plane shall be based on the effective diameter except that for bolts with threads included in the shear plane, the effective shear area shall be based on the root diameter.

5.1.4 Bearing Area. The effective bearing area of rivets or bolts shall be the effective diameter multiplied by the length in bearing except that for countersunk rivets, half of the depth of the countersink shall be deducted from the length.

5.1.5 Arrangements and Strength of Connections. Insofar as possible connections shall be arranged so that the center of resistance of the connection shall coincide with the resultant line of action of the load. Where eccentricity exists members and connections shall be proportioned to take into account any eccentricity of loading at the connections.

5.1.6 Net Section. The net section of a riveted or bolted tension member shall be determined as the sum of the net sections of its component parts. The net section of a part is the product of the thickness of the part multiplied by its least net width. The net width for a chain of holes extending across the part in any straight or broken line shall be obtained by deducting from the gross width the sum of the diameters of all the holes in the chain and adding $s^2/4g$ for each gage space in the chain. In the correction quantity $s^2/4g$, s denotes spacing parallel to the direction of the load (pitch) of any two successive holes in the chain, in inches, and g refers to gage, the spacing perpendicular to the direction of the load of the same holes, in inches.

The net section of the part shall be obtained from that chain which gives the least net width. The hole diameter to be deducted shall be the actual hole diameter for drilled or reamed holes and the hole diameter plus 1/32 inch for punched holes.

For angles, the gross width shall be the sum of the widths of the legs less the thickness. The gage for holes in opposite legs shall be the sum of the gages from the back of the angles, less the thickness.

For splice members, the thickness shall be only that part of the thickness of the member that has been developed by rivets or bolts, beyond the section considered.

5.1.7 Effective Sections of Angles. If a discontinuous angle (single or paired) in tension is connected to one side of a gusset plate, the effective net section shall be the net section of the connected leg plus one-third of the section of the outstanding leg unless the outstanding leg is connected by a lug angle. In the latter case, the effective net section shall be the entire net section of the angle. The lug angle shall be designed to develop at least one-half the total load in the member and shall be connected to the main member by at least two fasteners.

For double angles placed back-to-back and connected to both sides of a gusset plate, the effective net section shall be the net section of the connected legs plus two-thirds of the section of the outstanding legs.

mechanical connections

For intermediate joints of continuous angles, the effective net area shall be the gross sectional area less deductions for holes.

5.1.8 Grip of Rivets and Bolts. If the grip (total thickness of metal being fastened) of rivets or bolts carrying calculated stress exceeds four and one-half times the diameter, the allowable load per rivet or bolt shall be reduced. The reduced allowable load shall be the normal allowable load divided by $[\frac{1}{2} + G/(9D)]$ in which G is the grip and D is the nominal diameter of the rivet or bolt. If the grip of the rivet exceeds six times the diameter, special care shall be taken to insure that holes will be filled completely.

5.1.9 Spacing of Rivets and Bolts. Minimum distance of rivet centers shall be 3 times the nominal rivet diameter; minimum distance of bolt centers shall be $2\frac{1}{2}$ times the nominal bolt diameter. In built-up compression members the pitch in the direction of stress shall be such that the allowable stress on the individual outside sheets and shapes, treated as columns having a length equal to the rivet or bolt pitch exceeds the calculated stress. The gage at right angles to the direction of stress shall be such that the allowable stress in the outside sheets, calculated from Section 3.4.9 exceeds the calculated stress. In this case the width b in Section 3.4.9 may be taken as $0.8s$ where " s " is the gage in inches.

TABLE 5.1.1a
ALLOWABLE BEARING STRESSES
FOR BUILDING TYPE STRUCTURES

(F_{by} From Table 3.3.1a Divided By 1.65 Factor of Safety or F_{bu} Divided By 1.2×1.95)

Alloy And Temper	Allowable Bearing Stress* ksi	Alloy And Temper	Allowable Bearing Stress* ksi
1100-H12.....	11.0	5050-H32.....	16
-H14.....	12.5	-H34.....	19
2014-T6 Sheet	53	5052-H32.....	24
-T651 Plate	54	-H34.....	27
-T6,T6510,T6511 Extrusions	49	5083-H111.....	25
-T6, T651 Rolled Bar.....	53	-H321 (0.188 to 1.500)*.....	32
Drawn Tube		-H321 (1.501 to 3.000)*.....	30
Alclad		-H323.....	35
2014-T6 Sheet (up to 0.039)*.....	53.4	-H343.....	40
-T6, T651 Sheet, Plate.....	55.2	5086-H111.....	22
3003-H12.....	11.5	-H112 (0.188 to 0.499)*.....	19
-H14.....	15	-H112 (0.500 to 3.000)*.....	17.0
-H16.....	19	-H32.....	29
-H18.....	21	-H34.....	35
Alclad		5454-H111.....	19
3003-H12.....	11	-H112.....	14.5
-H14.....	14.5	-H32.....	27
-H16.....	18	-H34.....	30
-H18.....	19	5456-H111.....	27
3004-H32.....	22	-H112.....	23
-H34.....	24	-H321 (0.188 to 1.250)*.....	34
-H36.....	27	-H321 (1.251 to 1.500)*.....	32
Alclad		-H321 (1.501 to 3.000)*.....	30
3004-H32.....	21	-H323.....	37
-H34.....	23	-H343.....	42
-H14.....	24	6061-T6,T651 Sheet & Plate	35
-H16.....	27	-T6,T651,T6510,T6511 Other Products	34
5005-H12.....	13.5	6063-T5 (up to 0.500)*.....	16
-H14.....	15	-T5 (Over 0.500)*.....	14.5
-H32.....	12	-T6.....	24
-H34.....	14.5		

*Thickness in inches to which the allowable stress applies. Where not listed, bearing stress applies to all thicknesses.

TABLE 5.1.1b
ALLOWABLE STRESSES FOR RIVETS
FOR BUILDING TYPE STRUCTURES

Designation Before Driving	Driving Procedure	Designation After Driving	Minimum Expected Shear Strength ksi	Allowable* Shear Stress on Effective Area ksi
1100-H14	Cold, as received	1100-F	9.5	4
2017-T4	Cold, as received	2017-T3	34	14.5
2117-T4	Cold, as received	2117-T3	29	12
5056-H32	Cold, as received	5056-H321	26	11
6053-T61	Cold, as received	6053-T61	20	8.5
6061-T4	Hot, 990° to 1,050°F	6061-T43	21	9
6061-T6	Cold, as received	6061-T6	26	11†

† Also applies to 6061-T6 Pins.

* Minimum expected shear strength divided by 2.34. See Table 3.3.3.

ALLOWABLE STRESSES FOR BOLTS
FOR BUILDING TYPE STRUCTURES

Alloy And Temper	Minimum Expected Shear Strength ksi	Allowable* Shear Stress on Effective Area ksi	Allowable Tensile Stress on Root Area ksi
2024-T4	37	16	26
6061-T6	27	12	18
7075-T73	40	17	28

*Values apply to either turned bolts or unfinished bolts in holes not more than $\frac{1}{16}$ in. oversized.

5.1.10 Stitch Rivets and Bolts. Where two or more web plates are in contact, there shall be stitch rivets or bolts to make them act in unison. In compression members, the pitch and gage of such rivets or bolts shall be determined as outlined in Section 5.1.9. In tension members, the maximum pitch or gage of such rivets or bolts shall not exceed a distance, in inches, equal to $(3 + 20t)$ in which t is the thickness of the outside plates, in inches.

5.1.11 Edge Distance of Rivets or Bolts. The distance from the center of rivet or bolt under computed stress to the edge of the sheet or shape toward which the pressure is directed shall be twice the nominal diameter of the rivet or bolt. When a shorter edge distance is used, the allowable bearing stress as shown in Table 5.1.1a shall be reduced by the ratio: actual edge distance/twice rivet or bolt diameter (See Section 3.4.5). The edge distance shall not be less than 1.5 times the rivet or bolt diameter to sheared, sawed, rolled or planed edges.

5.1.12 Blind Rivets. Blind rivets may be used only when the grip lengths and rivet-hole tolerances are as recommended by the respective manufacturers.

5.1.13 Hollow-End Rivets. If hollow-end rivets with solid cross sections for a portion of the length are used, the strength of these rivets may be taken equal to the strength of solid rivets of the same material, provided that the bottom of the cavity is at least 25 percent of the rivet diameter from the plane of shear, as measured toward the hollow-end, and further provided that they are used in locations where they will not be subjected to appreciable tensile stresses.

5.1.14 Steel Rivets. Steel rivets shall not be used in aluminum structures unless the aluminum is to be joined to steel or where corrosion resistance of the structure is not a requirement, or where the structure is to be protected against corrosion (See Section 6.6.1).

fabrication

5.1.15 Lockbolts. Lockbolts may be used when installed in conformance with the lockbolt manufacturer's recommended practices and provided the body diameter and bearing areas under the head and nut, or their equivalent, are not less than those of a conventional nut and bolt.

5.1.16 Steel Bolts. Hot-dip galvanized, electro-galvanized, or aluminized steel bolts, 300 series stainless steel bolts and double cadmium plated AN bolts may be used instead of aluminum bolts.

5.2 Thread Forming (Tapping) Screws and Metal Stitching Staples. If joints carrying calculated loads are to be made with thread forming screws or metal stitches, allowable strength values for these connections shall be established on the basis of specific acceptable tests.

Thread forming (tapping) screws and metal stitching staples find an increasing application in joining of light gage structures. In view of the wide variance of joint strength obtainable with these fastening methods, no standard or uniform load allowables are recommended.

Section 6. Fabrication

6.1 Laying Out.

- a. Hole centers may be center punched and cutoff lines may be punched or scribed. Center punching and scribing shall not be used where such marks would remain on fabricated material.
- b. A temperature correction shall be applied where necessary in the layout of critical dimensions. The coefficient of expansion shall be taken as 0.000012 per degree Fahrenheit.

6.2 Cutting.

- a. Material may be sheared, sawed, cut with a router, or arc cut. All edges which have been cut by the arc process shall be planed to remove edge cracks.
- b. Cut edges shall be true and smooth, and free from excessive burrs or ragged breaks.
- c. Re-entrant cuts shall be avoided wherever possible. If used, they shall be filleted by drilling prior to cutting.
- d. Oxygen cutting of aluminum alloys shall not be permitted.

6.3 Heating. Structural material shall not be heated, with the following exceptions:

- a. Material may be heated to a temperature not exceeding 400°F for a period not exceeding 30 minutes in order to facilitate bending. Such heating shall be done only when proper temperature controls and supervision are provided to insure that the limitations on temperature and time are carefully observed.

6.4 Punching, Drilling, and Reaming. The following rules for punching, drilling, and reaming shall be observed:

- a. Rivet or bolt holes may be either punched or

drilled. Punching shall not be used if the metal thickness is greater than the diameter of the hole. The amount by which the diameter of a sub-punched hole is less than that of the finished hole shall be at least $\frac{1}{4}$ the thickness of the piece and in no case less than $\frac{1}{32}$ in.

- b. The finished diameter of holes for cold-driven rivets shall be not more than 4% greater than the nominal diameter of the rivet.
- c. The finished diameter of holes for hot-driven rivets shall be not more than 7 per cent greater than the nominal diameter of the rivet.
- d. The finished diameter of holes for bolts shall be not more than $\frac{1}{16}$ in. larger than the nominal bolt diameter.
- e. If any holes must be enlarged to admit the rivets or bolts, they shall be reamed. Poor matching of holes shall be cause for rejection. Holes shall not be drifted in such a manner as to distort the metal. All chips lodged between contacting surfaces shall be removed before assembly.

6.5 Riveting.

6.5.1 Driven Head. The driven head of aluminum alloy rivets shall be of the flat or the cone-point type, with dimensions as follows:

- a. Flat heads shall have a diameter not less than 1.4 times the nominal rivet diameter and a height not less than 0.4 times the nominal rivet diameter.
- b. Cone-point heads shall have a diameter not less than 1.4 times the nominal rivet diameter and a height to the apex of the cone not less than 0.65 times the nominal rivet diameter. The included angle at the apex of the cone shall be approximately 127°.

6.5.2 Hole Filling. Rivets shall fill the holes completely. Rivet heads shall be concentric with the rivet holes and shall be in proper contact with the surface of the metal.

6.5.3 Defective Rivets. Defective rivets shall be removed by drilling.

6.6 Painting. Structures of the alloys covered by these specifications are not ordinarily painted (with the exception of 2014-T6 when exposed to corrosive environments). Surfaces shall be painted where:

1. The aluminum alloy parts are in contact with, or are fastened to, steel members or other dissimilar materials.
2. The structures are to be exposed to extremely corrosive conditions, or for reason of appearance. Painting procedure is covered in the following Sections 6.6.1 and 6.6.2, and methods of cleaning and preparation are found in Section 6.7. (Treatment and painting of the structure in accordance with United States Military Specification MIL-T-704 is also acceptable.)

6.6.1 Contact with Dissimilar Materials. Where the aluminum alloy parts are in contact with, or are fas-

tened to, steel members or other dissimilar materials, the aluminum shall be kept from direct contact with the steel or other dissimilar material by painting as follows:

1. Aluminum surfaces to be placed in contact with steel shall be given one coat of zinc chromate primer in accordance with Federal Specification TT-P-645, or the equivalent, or one coat of a suitable nonhardening joint compound capable of excluding moisture from the joint during prolonged service. Where severe corrosion conditions are expected, additional protection can be obtained by applying the joint compound in addition to the zinc chromate primer. Zinc chromate paint shall be allowed to dry hard (air dry 24 hours) before assembly of the parts. The steel surfaces to be placed in contact with aluminum shall be painted with good quality priming paint, such as zinc chromate primer in accordance with Federal Specification TT-P-645, followed by one coat of paint consisting of 2 lb. of aluminum paste pigment (ASTM Specification D962-66, Type 2, Class B) per gallon of varnish meeting Federal Specification TT-V-81d, Type II, or the equivalent. Stainless steel, or aluminized, hot-dip galvanized or electro-galvanized steel placed in contact with aluminum need not be painted.
2. Aluminum surfaces to be placed in contact with wood, concrete, or masonry construction, except where the aluminum is to be embedded in concrete, shall be given a heavy coat of an alkali-resistant bituminous paint before installation. The bituminous paint used shall meet the requirements of United States Military Specification MIL-P-6883. The paint shall be applied as it is received from the manufacturer without the addition of any thinner.
3. Aluminum surfaces to be embedded in concrete ordinarily need not be painted, unless corrosive components are added to the concrete or unless the concrete is subjected for extended periods to extremely corrosive conditions. In such cases, aluminum surfaces shall be given one coat of suitable quality paint, such as zinc chromate primer conforming to Federal Specification TT-P-645 or equivalent, or shall be wrapped with a suitable plastic tape applied in such a manner as to provide adequate protection at the overlap.
4. Water that comes in contact with aluminum after first running over a heavy metal such as copper may contain trace quantities of the dissimilar metal or its corrosion product, which will cause corrosion of the aluminum. Protection shall be obtained by painting or plastic coating the dissimilar metal or by designing the structure so that the drainage from the dissimilar metal is diverted away from the aluminum.

6.6.2 Over-All Painting. Structures of the alloys covered by these specifications are either not ordinarily painted for surface protection (with the exception of 2014-T6 when exposed to corrosive environments) or are made of prepainted aluminum components. There may be applications where the structures are to be exposed to extremely corrosive conditions. In these cases over-all painting shall be specified.

6.7 Cleaning and Treatment of Metal Surfaces. Prior to field painting of structures, all surfaces to be painted shall be cleaned immediately before painting, by a method that will remove all dirt, oil, grease, chips, and other foreign substances.

Exposed metal surfaces shall be cleaned with a suitable chemical cleaner such as a solution of phosphoric acid and organic solvents meeting United States Military Specification MIL-M-10578. If the metal is more than $\frac{1}{8}$ in. thick, sandblasting may be used.

Section 7. Welded Construction

7.1 Allowable Stresses for Welded Parts.

7.1.1 General. Most of the structural aluminum alloys attain their strength by heat treatment or strain hardening. Welding causes local annealing which produces a zone of lower strength along both sides of the weld bead. The resulting variation in mechanical properties in the vicinity of a weld is illustrated by the typical distribution of yield strength in Fig. 7.1.1. When designing welded load carrying members this decrease in strength shall be taken into consideration in addition to the design rules as outlined in Section 3.

7.1.2 Allowable Stresses for Welded Members. Allowable stresses for welded members shall be determined from the same formulas that are used for nonwelded members. These formulas are given in Table 3.3.6. In applying these formulas to welded structures, the tensile ultimate strength, F_{tuw} , shall be 90 percent of the ASME weld qualification test value of ultimate strength given in Table 3.3.2. The yield strengths, F_{tyw} and F_{cyw} , shall be the tensile and compressive yield strengths, given in Table 3.3.2.

In general, welds have little effect on buckling strength except in the range of slenderness ratios where the allowable stress is controlled by the welded yield strength. Parent metal values of the buckling formula constants are then used for welded members. An exception is the case of welded tubes, Sections 3.4.10, 3.4.12, for which the buckling formula coefficients are determined from the formulas in Table 3.3.4a, using the 10-in. gage length compressive yield strength F_{cyw} from Table 3.3.2. Another exception is a column with welds at locations other than the ends (or a cantilever column with a weld at the end). This exception is discussed in Section 7.1.5 below.

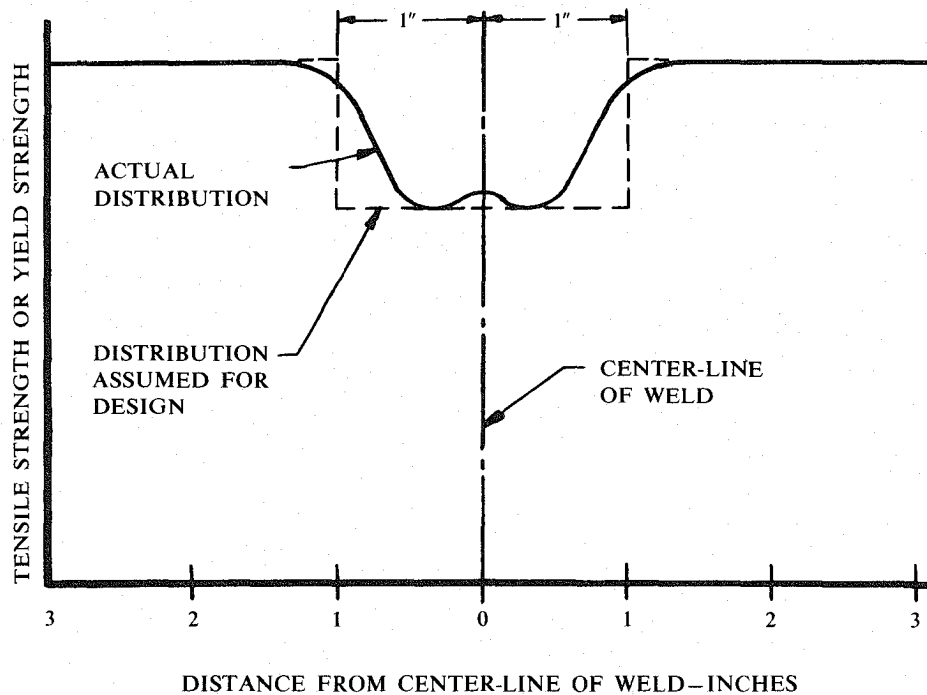


Figure 7.1.1 Distribution of Mechanical Properties in the Vicinity of a Weld

7.1.3 Filler Wire. The choice of filler metal for general purpose welding shall be those alloys listed in Table 7.1.3.1; the allowable shear stresses in fillet welds shall be those listed in Table 7.1.3.2.

The amount of loss of properties depends to a large extent on the alloy and temper of the components involved. The filler wire used also influences the strength of the weld, especially the shear strength.

7.1.4 Cross Section With Part of Area Affected by Heat of Welding. If less than 15% of the area of a given cross section lies within 1 in. of a weld, regardless of material thickness, the effect of welding may be neglected and allowable stresses calculated as outlined in Section 3. If A_w is equal to or greater than 15% of A the allowable stress shall be calculated from

$$F_{pw} = F_n - \frac{A_w}{A} (F_n - F_w)$$

where:

F_{pw} = allowable stress on cross section, part of whose area lies within 1.0 in. of a weld

F_n = allowable stress for cross section 1.0 in. or more from weld

F_w = allowable stress on cross section if entire area were to lie within 1.0 in. of a weld

A_w = area of cross section lying within 1.0 in. of a weld

A = net area of cross section of a tension member or tension flange of a beam, or gross area of cross section of a compression member or compression flange of a beam, in.² (a beam flange is considered to consist

of that portion of the member further than $2c/3$ from the neutral axis, where c is the distance from the neutral axis to the extreme fiber.)

7.1.5 Columns And Single-Web Beams With Welds at Locations Other Than Ends, And Cantilever Columns And Single Web Beams. The allowable stresses in Section 3 apply to members supported at both ends with welds at the ends only (not farther from the supports than $0.05 L$ from the ends).

For columns with transverse welds at locations other than the supports, cantilever columns with transverse welds at or near the supported end and columns with longitudinal welds having A_w equal to or greater than 15% of A , the effect of welding on column strength shall be taken into account by using an increased slenderness ratio L_w/r , in the column formula, as follows:

$$\text{If } \frac{L}{r} > \sqrt{\frac{250000}{F_{cyw}}}, \frac{L_w}{r} = \frac{L}{r}$$

$$\text{If } \frac{L}{r} \leq \sqrt{\frac{250000}{F_{cyw}}};$$

$$\frac{L_w}{r} = \frac{L}{r} \sqrt{\frac{1 + 100 \frac{L_h}{L}}{1 + \left(\frac{L_h}{L}\right) \left(\frac{L}{r}\right)^2 \left(\frac{F_{cyw}}{2500}\right)}}$$

where:

L_h = total length of portion of column lying within 1.0 in. of a weld (excluding welds at ends of columns that are supported at both ends)

TABLE 7.1.3.1
GUIDE TO THE CHOICE OF ALUMINUM FILLER ALLOYS
FOR GENERAL PURPOSE WELDING

Base Metal → Welded To Base Metal ↘	6061 6063	5456	5454	5154	5086	5083	5052	5005 5050	3004 Alclad 3004	1100 3003 Alclad 3003
1100, 3003 Alclad 3003	4043	5356 ^b	4043 ^a	4043 ^a	5356 ^b	5356 ^b	4043 ^a	4043 ^a	4043 ^a	1100 ^b
3004, Alclad 3004	4043 ^c	5356 ^a	5356 ^a	5356 ^a	5356 ^a	5356 ^a	5356 ^{ab}	4043 ^a	4043 ^a	
5005, 5050	4043 ^c	5356 ^a	5356 ^{ab}	5356 ^{ab}	5356 ^a	5356 ^a	4043 ^a	4043 ^{ad}		
5052	5356 ^{bc}	5356 ^a	5356 ^{bc}	5356 ^c	5356 ^a	5356 ^a	5356 ^{bc}			
5083	5356 ^a	5183 ^a	5356 ^a	5356 ^a	5356 ^a	5183 ^a				
5086	5356 ^a	5356 ^a	5356 ^c	5356 ^c	5356 ^a					
5154	5356 ^{bc}	5356 ^c	5356 ^c	5356 ^c						
5454	5356 ^{bc}	5356	5554 ^{ab}							
5456	5356 ^a	5556 ^a								
6061, 6063	4043 ^{ce}									

a—5356, 5183 or 5556 may be used.

b—4043 may be used for some applications.

c—5154, 5254, 5183, 5356 and 5556 may be used. In some cases they provide: (1) improved color match after anodizing treatment, (2) highest weld ductility and (3) higher weld strength. 5554 is suitable for elevated temperature service.

d—Filler metal with the same analysis as the base metal is sometimes used.

e—4643 may be used and is often desirable so as to provide highest strength in postweld heat-treated assemblies.

TABLE 7.1.3.2
ALLOWABLE SHEAR STRESSES IN FILLET WELDS-ksi*
 (Shear Stress Is Considered To Be Equal To The Load Divided By The Throat Area)

Filler Alloy‡	1100	4043	5356 5554	5556
Parent Alloy				
1100	3.2	4.8†	—	—
3003	3.2	5	—	—
Alclad 3004		5	7	8†
5052	—	5	7	—
5083	—	—	—	8.5
5086	—	—	7	8.5
5454	—	—	7	8.5
5456	—	—	—	8.5
6061	—	5	7	8.5
6063	—	5	6.5†	6.5†

* Allowable stresses for building structures.

† Values controlled by the shear strength of the parent metal.

‡ Minimum expected shear strengths of filler alloys are:

Alloy 1100	7.5 ksi
4043	11.5
5356	17
5554	17
5556	20

testing

where:

F_{cyw} = compressive yield strength across a butt weld (0.2 percent offset in 10 in. gage length)

L_w = increased length to be substituted in column formula to determine allowable stress for welded column.

The above formulas assume that the entire cross section within the length L_h is affected by the heat of welding. If only part of the cross section is so affected, the allowable stress based on L_w/r shall be substituted for F_w in the formula in Section 7.1.4.

7.2 Welding Fabrication.

7.2.1 General. These specifications are proposed for application to both field and shop welding operations. The general recommendations and regulations shown in the American Welding Society Specifications D2.0-66 "Welded Highway and Railway Bridges" 1966 and D1.0-66 "Code for Arc and Gas Welding in Building Construction" 1966 shall apply as well to welded aluminum structures. Detail requirements in the above specifications apply only to steel structures. Detail requirements for welded aluminum alloys are given in the following paragraphs.

7.2.2 Preparation for Welding. Dirt, grease, forming or machining lubricants, or any organic materials shall be removed from the areas to be welded by cleaning with a suitable solvent or by vapor degreasing. The oxide coating shall be removed just prior to welding. This may be done by etching or scratch brushing.

Suitable edge preparation to assure 100% penetration in butt welds shall be used. Oxygen cutting shall not be used. Sawing, chipping, machining, shearing, or arc cutting may be used. (See also Section 6.2)

7.2.3 Welding Procedure. Parts shall be welded with an inert gas shielded arc or resistance welding process. No welding process that requires a welding flux shall be used. The filler metal shall be an aluminum alloy as listed in Table 7.1.3.1. Other filler metal alloys may be used provided that they are capable of meeting the qualification test requirements, and result in welds having resistance to corrosion equal to or greater than welds made with the listed filler alloys. Preheating for welding is permissible, provided the temperature does not exceed 400°F for a total time of 30 minutes.

7.2.4 Qualification of Welding Procedure and Welding Operators. The welding process and welding operators shall both meet a qualification test. The method of qualification shall be mutually established by the inspecting agency and the contractor or shall conform to the method described in the ASME Boiler and Pressure Vessel Code, Section IX, "Welding Qualifications," Part B, 1965. Aluminum alloys as required shall be used for the qualification test plates.

The minimum required tensile strength of reduced section specimens in the procedure qualification test is

to be established from Table 3.3.2. In addition to the tensile test, side-bend, or face-bend and root-bend tests (either longitudinal or transverse) are required. Operators shall be qualified on the basis of bend tests and a fillet weld soundness test.

7.2.5 Rewelding Defects. Portions of joints that have been rejected on inspection because of defects may be repaired only by rewelding. The defective area shall be removed by chipping or machining. Flame cutting shall not be used. Before rewelding, the joint shall be inspected to assure that all of the defective weld metal has been removed and that the joint is accessible so that the welding operator can obtain full penetration through the joint.

Section 8. Testing

8.1 General

Testing shall be considered an acceptable method for substantiating the design of aluminum alloy load carrying members. Tests shall be conducted by an independent testing laboratory or by a manufacturer's testing laboratory.

8.2 Test Loading and Behavior

In order to test a structure or load carrying member adequately, the loading shall be applied in a fashion that reasonably approximates the application of the loading during service. Further, the structure or member shall be supported in a manner that is no more sustaining to the structure than will be the supports available when the structure is in service.

Determinations of allowable load-carrying capacity shall be made on the basis that the member, assembly, or connection shall be capable of sustaining during the test without failure a total load, including the weight of the test specimen, equal to twice the live load plus one-and-one-half the dead load. Furthermore, harmful local distortions shall not develop during the test at a total load, including the weight of the test specimen, equal to the dead load plus one-and-one-half times the live load.

Where practicable, evaluation of test results shall be made on the basis of the mean values resulting from tests of not fewer than three identical specimens, provided the deviation of any individual test result from the mean value obtained from all tests does not exceed $\pm 10\%$. If such deviation from the mean exceeds 10%, at least three more tests of the same kind shall be made. The average of the three lowest values of all tests made shall then be regarded as the result of the series of tests.

In evaluating test results, due consideration must be given to any differences that may exist between the yield strength of the material from which the tested sections are formed and the minimum yield strength specified for the material which the manufacturer intends to use.

BIBLIOGRAPHY

These specifications have their origins in many places. This bibliography is intended for those who want to find out more about some of the specific structural design situations covered in the body of these specifications.

Rather complete bibliographies through 1962 are given in the following ASCE papers:

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Works of interest published since that time include the following:

3. "Handbook of Design Stresses For Aluminum", Aluminum Company of America, 1966.
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11. "Buckling of Aluminum Columns, Plates, and Beams", by J. W. Clark and R. L. Rolf, Proceedings of the American Society of Civil Engineers, Journal of the Structural Division, June, 1966.
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APPENDIX

Allowable Stresses for Bridge and Similar Type Structures

The Tables on the succeeding pages follow the formulas in Table 3.3.6 and are based on the basic factors of safety for bridge structures of $n_u = 2.20$ and $n_y = 1.85$ given in Table 3.3.3.

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table A.1 Allowable Stresses for BRIDGE and Similar Type Structures			
TENSION, axial, net section	Any tension member:	1	17	10 [Ⓢ]	6061-T6, -T651, -T6510, -T6511 Extrusions, Sheet and Plate, Standard Structural Shapes, Rolled Rod and Bar, Drawn Tube, Pipe			
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	17	10 [Ⓢ]				
	Round or oval tubes	3	21	12 [Ⓢ]				
	Rectangular bars, plates, shapes bent about weak axis	4	25	14 [Ⓢ]				
BEARING	On rivets and bolts	5	30	16 [Ⓢ]				
	On flat surfaces and pins	6	20	11 [Ⓢ]				
			Allowable Stress, ksi, Slenderness ≤ S ₁	Slenderness Limit, S ₁	Allowable Stress, ksi Slenderness Between S ₁ and S ₂	Slenderness Limit, S ₂	Allowable Stress, ksi Slenderness ≥ S ₂	
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	17	$\frac{L}{r} = 8.0$	$17.9-0.112\frac{L}{r}$	$\frac{L}{r} = 66$	$\frac{45,000}{(L/r)^2}$	
			11 [Ⓢ]	$\frac{L}{r} = 62^{\circ}$	$17.9-0.112\frac{L}{r}$	$\frac{L}{r} = 66$	$\frac{45,000}{(L/r)^2}$	
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	17	$\frac{b}{t} = 5.0$	$20.5-0.70\frac{b}{t}$	$\frac{b}{t} = 12$	$\frac{1,740}{(b/t)^2}$	
			11 [Ⓢ]	---	11 [Ⓢ]	$\frac{b}{t} = 13^{\circ}$	$\frac{1,740}{(b/t)^2}$	
	Flat plates with both edges supported	9	17	$\frac{b}{t} = 16$	$20.5-0.22\frac{b}{t}$	$\frac{b}{t} = 33$	$\frac{430}{(b/t)}$	
			11 [Ⓢ]	---	11 [Ⓢ]	$\frac{b}{t} = 39^{\circ}$	$\frac{430}{(b/t)}$	
	Curved plates supported on both edges, walls of round or oval tubes	10	17	$\frac{R}{t} = 13$	$19.6-0.71\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 141$	$\frac{2,800}{(R/t)(1+\sqrt{R/t/35})^2}$	
			11 [Ⓢ]	$\frac{R}{t} = 5.2^{\circ}$	$12.0-0.44\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 290$	$\frac{2,800}{(R/t)(1+\sqrt{R/t/35})^2}$	
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	19	$\frac{L_b}{r_y} = 21$	$21.3-0.111\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 79$	$\frac{78,000}{(L_b/r_y)^2}$	
			11 [Ⓢ]	---	11 [Ⓢ]	$\frac{L_b}{r_y} = 84^{\circ}$	$\frac{78,000}{(L_b/r_y)^2}$	
	Round or oval tubes	12	22	$\frac{R_b}{t} = 29$	$35.0-2.4\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 83$	Same as Specification No. 10	
			12.5 [Ⓢ]	$\frac{R_b}{t} = 50^{\circ}$	$21.3-1.24\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 135$	Same as Specification No. 10	
	Solid rectangular beams	13	25	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 13$	$36.1-0.83\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 29$	$\frac{10,200}{(d/t)^2(L_b/d)}$	
			14 [Ⓢ]	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 27^{\circ}$	$36.1-0.83\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 29$	$\frac{10,200}{(d/t)^2(L_b/d)}$	
	Rectangular tubes and box sections	14	19	$\frac{L_b S_c}{I_y} = 120$	$21.3-0.21\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 1700$	$\frac{21,000}{(L_b S_c/I_y)}$	
			11 [Ⓢ]	---	11 [Ⓢ]	$\frac{L_b S_c}{I_y} = 1910^{\circ}$	$\frac{21,000}{(L_b S_c/I_y)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	19	$\frac{b}{t} = 6.4$	$24.3-0.83\frac{b}{t}$	$\frac{b}{t} = 10$	$\frac{162}{(b/t)}$	
			11 [Ⓢ]	---	11 [Ⓢ]	$\frac{b}{t} = 15^{\circ}$	$\frac{162}{(b/t)}$	
	Flat plates with both edges supported	16	19	$\frac{b}{t} = 20$	$24.3-0.26\frac{b}{t}$	$\frac{b}{t} = 33$	$\frac{520}{(b/t)}$	
			11 [Ⓢ]	---	11 [Ⓢ]	$\frac{b}{t} = 47^{\circ}$	$\frac{520}{(b/t)}$	
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	25	$\frac{b}{t} = 8.8$	$36.1-1.26\frac{b}{t}$	$\frac{b}{t} = 19$	$\frac{4,400}{(b/t)^2}$	
			14 [Ⓢ]	$\frac{b}{t} = 18^{\circ}$	$36.1-1.26\frac{b}{t}$	$\frac{b}{t} = 19$	$\frac{4,400}{(b/t)^2}$	
	Flat plates with both edges supported	18	25	$\frac{h}{t} = 46$	$36.1-0.24\frac{h}{t}$	$\frac{h}{t} = 75$	$\frac{1,350}{(h/t)}$	
			14 [Ⓢ]	---	14 [Ⓢ]	$\frac{h}{t} = 96^{\circ}$	$\frac{1,350}{(h/t)}$	
	Flat plates with horizontal stiffener, both edges supported	19	25	$\frac{h}{t} = 107$	$36.1-0.104\frac{h}{t}$	$\frac{h}{t} = 173$	$\frac{3,100}{(h/t)}$	
			14 [Ⓢ]	---	14 [Ⓢ]	$\frac{h}{t} = 221^{\circ}$	$\frac{3,100}{(h/t)}$	
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	11	$\frac{h}{t} = 33$	$13.9-0.089\frac{h}{t}$	$\frac{h}{t} = 65$	$\frac{34,000}{(h/t)^2}$	
			6.5 [Ⓢ]	---	6.5 [Ⓢ]	$\frac{h}{t} = 72^{\circ}$	$\frac{34,000}{(h/t)^2}$	
	Stiffened flat webs	21	11	---	11	$\frac{a_c}{t} = 65$	$\frac{47,000}{(a_c/t)^2}$	
	$a_e = a_1/\sqrt{1+0.7(a_1/a_2)^2}$		6.5 [Ⓢ]	---	6.5 [Ⓢ]	$\frac{a_c}{t} = 85^{\circ}$	$\frac{47,000}{(a_c/t)^2}$	

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

Ⓢ For all thicknesses with filler alloys 5356 or 5556. With filler alloys 4043 or 5554, values apply to metal 3/8 in. or less in thickness; for greater thicknesses multiply allowable stresses by 0.8.

Ⓢ For all thicknesses with filler alloys 5356 or 5556; for metal 3/8 in. or less in thickness with filler alloys 4043 or 5554.

Table A.2
Allowable Stresses for
BRIDGE and Similar
Type Structures

6063-T5

Extrusions, Pipe
(Thickness up thru
0.500 in.) •a

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table A.2 Allowable Stresses for BRIDGE and Similar Type Structures 6063-T5 Extrusions, Pipe (Thickness up thru 0.500 in.)		
TENSION, axial, net section	Any tension member:	1	8.5	6			
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis	2	8.5	6			
	Round or oval tubes	3	10	7			
	Rectangular bars, plates, shapes bent about weak axis	4	11	7.5			
BEARING	On rivets and bolts	5	14	12			
	On flat surfaces and pins	6	9.5	8			
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	7.5	$\frac{L}{r} = 12$	$7.9-0.033\frac{L}{r}$	$\frac{L}{r} = 99$	$\frac{45,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs	8	7.5	$\frac{b}{t} = 7$	$8.9-0.199\frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{1,740}{(b/t)^2}$
			6	$\frac{b}{t} = 15$	$8.9-0.199\frac{b}{t}$	$\frac{b}{t} = 18$	$\frac{1,740}{(b/t)^2}$
	Flat plates with both edges supported	9	7.5	$\frac{b}{t} = 22$	$8.9-0.063\frac{b}{t}$	$\frac{b}{t} = 50$	$\frac{290}{(b/t)}$
			6	$\frac{b}{t} = 46$	$8.9-0.063\frac{b}{t}$	$\frac{b}{t} = 50$	$\frac{290}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes	10	7.5	$\frac{R}{t} = 25$	$8.7-0.24\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 270$	$\frac{2,800}{(R/t)(1 + \sqrt{R/t/35})^2}$
			6	$\frac{R}{t} = 4.3$	$6.4-0.193\sqrt{\frac{R}{t}}$	$\frac{R}{t} = 510$	$\frac{2,800}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis	11	8.5	$\frac{L_b}{r_y} = 28$	$9.4-0.032\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 119$	$\frac{78,000}{(L_b/r_y)^2}$
			6	$\frac{L_b}{r_y} = 106$	$9.4-0.032\frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 119$	$\frac{78,000}{(L_b/r_y)^2}$
	Round or oval tubes	12	10	$\frac{R_b}{t} = 47$	$15.6-0.82\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 142$	Same as Specifica- tion No. 10
			7	$\frac{R_b}{t} = 66$	$11.4-0.54\sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 208$	Same as Specifica- tion No. 10
	Solid rectangular beams	13	11	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 19$	$15.3-0.23\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 45$	$\frac{10,200}{(d/t)^2(L_b/d)}$
			7.5	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 34$	$15.3-0.23\frac{d}{t}\sqrt{\frac{L_b}{d}}$	$\frac{d}{t}\sqrt{\frac{L_b}{d}} = 45$	$\frac{10,200}{(d/t)^2(L_b/d)}$
	Rectangular tubes and box sections	14	8.5	$\frac{L_b S_c}{I_y} = 211$	$9.4-0.062\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3830$	$\frac{21,000}{(L_b S_c/I_y)}$
			6	$\frac{L_b S_c}{I_y} = 3010$	$9.4-0.062\sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 3830$	$\frac{21,000}{(L_b S_c/I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges	15	8.5	$\frac{b}{t} = 8.3$	$10.5-0.24\frac{b}{t}$	$\frac{b}{t} = 16$	$\frac{107}{(b/t)}$
			6	---	6	$\frac{b}{t} = 18$	$\frac{107}{(b/t)}$
	Flat plates with both edges supported	16	8.5	$\frac{b}{t} = 27$	$10.5-0.074\frac{b}{t}$	$\frac{b}{t} = 50$	$\frac{340}{(b/t)}$
			6	---	6	$\frac{b}{t} = 57$	$\frac{340}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported	17	11	$\frac{b}{t} = 12$	$15.3-0.35\frac{b}{t}$	$\frac{b}{t} = 29$	$\frac{4,400}{(b/t)^2}$
			7.5	$\frac{b}{t} = 22$	$15.3-0.35\frac{b}{t}$	$\frac{b}{t} = 29$	$\frac{4,400}{(b/t)^2}$
	Flat plates with both edges supported	18	11	$\frac{h}{t} = 65$	$15.3-0.066\frac{h}{t}$	$\frac{h}{t} = 115$	$\frac{880}{(h/t)}$
			7.5	---	7.5	$\frac{h}{t} = 117$	$\frac{880}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported	19	11	$\frac{h}{t} = 148$	$15.3-0.029\frac{h}{t}$	$\frac{h}{t} = 270$	$\frac{2,000}{(h/t)}$
			7.5	---	7.5	$\frac{h}{t} = 270$	$\frac{2,000}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs	20	4.9	$\frac{h}{t} = 42$	$5.9-0.024\frac{h}{t}$	$\frac{h}{t} = 99$	$\frac{34,000}{(h/t)^2}$
			3.5	---	3.5	$\frac{h}{t} = 99$	$\frac{34,000}{(h/t)^2}$
	Stiffened flat webs	21	4.9	---	4.9	$\frac{a_e}{t} = 98$	$\frac{47,000}{(a_e/t)^2}$
			3.5	---	3.5	$\frac{a_e}{t} = 116$	$\frac{47,000}{(a_e/t)^2}$

WHITE BARS

apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS

apply within 1.0 in. of a weld.

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member:	1	13.5	6
TENSION IN BEAMS, extreme fiber, net section		Rectangular tubes, structural shapes bent about strong axis	2	13.5	6
		Round or oval tubes	3	16	7
		Rectangular bars, plates, shapes bent about weak axis	4	18	7.5
BEARING		On rivets and bolts	5	22	12
		On flat surfaces and pins	6	14.5	8

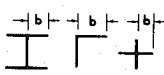
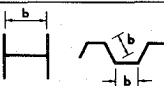
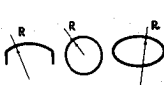
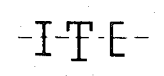
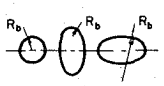
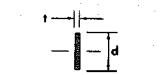
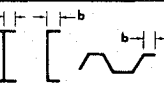
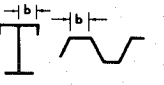
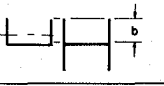
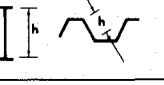
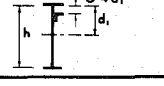
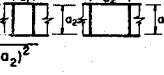
			Allowable Stress, ksi, Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		12	$\frac{L}{r} = 7.6$	$12.5 - 0.066 \frac{L}{r}$	$\frac{L}{r} = 78$	$\frac{45,000}{(\frac{L}{r})^2}$
			6	---	6	$\frac{L}{r} = 87$	$\frac{45,000}{(\frac{L}{r})^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs		12	$\frac{b}{t} = 5.6$	$14.3 - 0.41 \frac{b}{t}$	$\frac{b}{t} = 15$	$\frac{1,740}{(\frac{b}{t})^2}$
			6	---	6	$\frac{b}{t} = 17$	$\frac{1,740}{(\frac{b}{t})^2}$
	Flat plates with both edges supported		12	$\frac{b}{t} = 18$	$14.3 - 0.127 \frac{b}{t}$	$\frac{b}{t} = 39$	$\frac{360}{(\frac{b}{t})}$
			6	---	6	$\frac{b}{t} = 60$	$\frac{360}{(\frac{b}{t})}$
	Curved plates supported on both edges, walls of round or oval tubes		12	$\frac{R}{t} = 19$	$13.9 - 0.44 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 188$	$\frac{2,800}{(\frac{R}{t})(1 + \sqrt{R/t/35})^2}$
			6	$\frac{R}{t} = 4.3$	$6.4 - 0.193 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 510$	$\frac{2,800}{(\frac{R}{t})(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis		13.5	$\frac{L_b}{r_y} = 22$	$14.9 - 0.065 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 94$	$\frac{78,000}{(\frac{L_b}{r_y})^2}$
			6	---	6	$\frac{L_b}{r_y} = 114$	$\frac{78,000}{(\frac{L_b}{r_y})^2}$
	Round or oval tubes		16	$\frac{R_b}{t} = 33$	$24.7 - 1.51 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 102$	Same as Specification No. 10
			7	$\frac{R_b}{t} = 66$	$11.4 - 0.54 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 208$	Same as Specification No. 10
	Solid rectangular beams		18	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 15$	$24.9 - 0.47 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 35$	$\frac{10,200}{(\frac{d}{t})^2 (\frac{L_b}{d})}$
			7.5	---	7.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 37$	$\frac{10,200}{(\frac{d}{t})^2 (\frac{L_b}{d})}$
	Rectangular tubes and box sections		13.5	$\frac{L_b S_c}{I_y} = 125$	$14.9 - 0.125 \sqrt{\frac{L_b S_c}{I_y}}$	$\frac{L_b S_c}{I_y} = 2380$	$\frac{21,000}{(\frac{L_b S_c}{I_y})}$
			6	---	6	$\frac{L_b S_c}{I_y} = 3500$	$\frac{21,000}{(\frac{L_b S_c}{I_y})}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges		13.5	$\frac{b}{t} = 7.3$	$17.0 - 0.48 \frac{b}{t}$	$\frac{b}{t} = 12$	$\frac{135}{(\frac{b}{t})}$
			6	---	6	$\frac{b}{t} = 23$	$\frac{135}{(\frac{b}{t})}$
	Flat plates with both edges supported		13.5	$\frac{b}{t} = 23$	$17.0 - 0.151 \frac{b}{t}$	$\frac{b}{t} = 39$	$\frac{430}{(\frac{b}{t})}$
			6	---	6	$\frac{b}{t} = 72$	$\frac{430}{(\frac{b}{t})}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported		18	$\frac{b}{t} = 9.6$	$24.9 - 0.72 \frac{b}{t}$	$\frac{b}{t} = 23$	$\frac{4,400}{(\frac{b}{t})}$
			7.5	---	7.5	$\frac{b}{t} = 24$	$\frac{4,400}{(\frac{b}{t})^2}$
	Flat plates with both edges supported		18	$\frac{h}{t} = 50$	$24.9 - 0.138 \frac{h}{t}$	$\frac{h}{t} = 90$	$\frac{1,120}{(\frac{h}{t})}$
			7.5	---	7.5	$\frac{h}{t} = 149$	$\frac{1,120}{(\frac{h}{t})}$
	Flat plates with horizontal stiffener, both edges supported		18	$\frac{h}{t} = 115$	$24.9 - 0.060 \frac{h}{t}$	$\frac{h}{t} = 209$	$\frac{2,600}{(\frac{h}{t})}$
			7.5	---	7.5	$\frac{h}{t} = 350$	$\frac{2,600}{(\frac{h}{t})}$
SHEAR IN WEBS, gross section	Unstiffened flat webs		7.5	$\frac{h}{t} = 40$	$9.5 - 0.050 \frac{h}{t}$	$\frac{h}{t} = 78$	$\frac{34,000}{(\frac{h}{t})^2}$
			3.5	---	3.5	$\frac{h}{t} = 99$	$\frac{34,000}{(\frac{h}{t})^2}$
	Stiffened flat webs		7.5	---	7.5	$\frac{a_e}{t} = 79$	$\frac{47,000}{(\frac{a_e}{t})^2}$
		$a_e = a_1 \sqrt{1 + 0.7(a_1/a_2)^2}$	3.5	---	3.5	$\frac{a_e}{t} = 116$	$\frac{47,000}{(\frac{a_e}{t})^2}$

Table A.3
Allowable Stresses for
BRIDGE and Similar
Type Structures
6063-T6
Extrusions and Pipe

WHITE BARS apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS apply within 1.0 in. of a weld.

ADDENDUM

As additional alloys and tempers are approved for inclusion in these specifications they may be incorporated in this Addendum until the next revision of the publication.

Included in this second printing are alloys 5154-H38 sheet, 6351-T5 extrusions, and 6005-T5 extrusions.

Allowable stress tables A.4 for alloy 5154-H38 and A.5 for alloys 6351-T5 and 6005-T5 are given for

BRIDGE and similar type structures because of their prevalent use for such applications.

Data shown below are for future inclusion in Tables 3.3.1a and 3.3.1b and should also be used for determining allowable stresses for these alloys for BUILDING and similar type structures in accordance with Tables 3.3.3, 3.3.5, and 3.3.6.

TABLE 3.3.1a (addendum)
MINIMUM MECHANICAL PROPERTIES
FOR ALUMINUM ALLOYS

Values Are Given in Units of ksi (1000 lb/in²)

Alloy And Temper	Product	Thickness Range in.	TENSION		COM- PRES- SION <i>F_{cy}</i> ksi	SHEAR		BEARING		Compressive Modulus of Elasticity† <i>E</i> ksi
			<i>F_{tu}</i> † ksi	<i>F_{ty}</i> † ksi		<i>F_{su}</i> ksi	<i>F_{sy}</i> ksi	<i>F_{bu}</i> ksi	<i>F_{by}</i> ksi	
5154-H38	Sheet	0.006-0.128	45	35	33	24	20	81	56	10,300
6005-T5	Extrusions	up thru 0.500	38	35	35	24	20	80	56	10,100
6351-T5	Extrusions	up thru 1.00	38	35	35	24	20	80	56	10,100

† *F_{tu}* and *F_{ty}* are minimum specified values. Other strength properties are corresponding minimum expected values.

‡ For deflection calculations an average modulus of elasticity is used; numerically this is 100 ksi lower than the values in this column.

TABLE 3.3.1b (addendum)
BUCKLING FORMULA CONSTANTS FOR ALUMINUM ALLOYS

Alloy And Temper	Product	COMPRESSION IN COLUMNS			COMPRESSION IN FLAT PLATES			COMPRESSION IN ROUND TUBES		
		<i>B_c</i> ksi	<i>D_c</i> ksi	<i>C_c</i>	<i>B_p</i> ksi	<i>D_p</i> ksi	<i>C_p</i>	<i>B_t</i> ksi	<i>D_t</i> ksi	<i>C_t</i>
5154-H38	Sheet	39.0	0.294	89	46.9	0.388	81	44.4	1.956	185
6005-T5	Extrusions	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141
6351-T5	Extrusions	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141

		BENDING IN ROUND TUBES			BENDING IN REC- TANGULAR BARS			SHEAR IN FLAT PLATES		
		<i>B_{tb}</i> ksi	<i>D_{tb}</i> ksi	<i>C_{tb}</i>	<i>B_b</i> ksi	<i>D_b</i> ksi	<i>C_b</i>	<i>B_s</i> ksi	<i>D_s</i> ksi	<i>C_s</i>
5154-H38	Sheet	66.7	4.602	71	62.6	0.597	70	28.8	0.186	103
6005-T5	Extrusions	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
6351-T5	Extrusions	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81

Type of Stress		Type of Member or Component	Spec. No.	Allowable Stress, ksi	
TENSION, axial, net section		Any tension member	1	19	8
		Rectangular tubes, structural shapes bent about strong axis	2	19	8
		Round or oval tubes	3	22	9.5
TENSION IN BEAMS, extreme fiber, net section		Rectangular bars, plates, shapes bent about weak axis	4	25	10.5
BEARING		On rivets and bolts	5	30	12.5
		On flat surfaces and pins	6	20	8

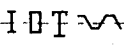
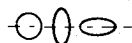
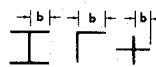
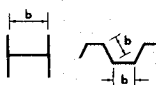
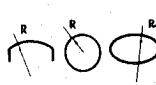
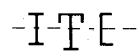
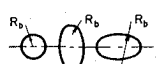
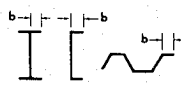
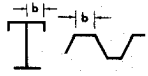
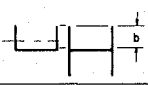
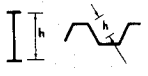
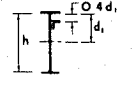
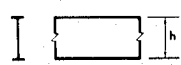
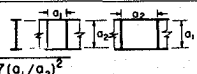
			Allowable Stress, ksi Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns		16	$\frac{L}{r} = 13$	$17.7 - 0.134 \frac{L}{r}$	$\frac{L}{r} = 89$	$\frac{46,000}{(L/r)^2}$
			8	$\frac{L}{r} = 72$	$17.7 - 0.134 \frac{L}{r}$	$\frac{L}{r} = 89$	$\frac{46,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs		16	$\frac{b}{t} = 5.9$	$21.3 - 0.90 \frac{b}{t}$	$\frac{b}{t} = 16$	$\frac{1,780}{(b/t)^2}$
			8	$\frac{b}{t} = 15$	$21.3 - 0.90 \frac{b}{t}$	$\frac{b}{t} = 16$	$\frac{1,780}{(b/t)^2}$
	Flat plates with both edges supported		16	$\frac{b}{t} = 19$	$21.3 - 0.28 \frac{b}{t}$	$\frac{b}{t} = 38$	$\frac{400}{(b/t)}$
			8	---	8	$\frac{b}{t} = 50$	$\frac{400}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes		16	$\frac{R}{t} = 22$	$20.2 - 0.89 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 185$	$\frac{2,900}{(R/t)(1 + \sqrt{R/t/35})^2}$
			8	$\frac{R}{t} = 7.1$	$8.8 - 0.30 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 410$	$\frac{2,900}{(R/t)(1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis		18	$\frac{L_b}{r_y} = 23$	$21.1 - 0.132 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 107$	$\frac{79,000}{(L_b/r_y)^2}$
			8	$\frac{L_b}{r_y} = 99$	$21.1 - 0.132 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 107$	$\frac{79,000}{(L_b/r_y)^2}$
	Round or oval tubes		21	$\frac{R_b}{t} = 36$	$36.1 - 2.5 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 98$	Same as Specification No. 10
			9.5	$\frac{R_b}{t} = 58$	$15.8 - 0.83 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 174$	Same as Specification No. 10
	Solid rectangular beams		23	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 15$	$33.8 - 0.74 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 30$	$\frac{10,400}{(d/t)^2 (L_b/d)}$
			10.5	---	10.5	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 31$	$\frac{10,400}{(d/t)^2 (L_b/d)}$
	Rectangular tubes and box sections		18	$\frac{L_b S_x}{I_y} = 154$	$21.1 - 0.25 \sqrt{\frac{L_b S_x}{I_y}}$	$\frac{L_b S_x}{I_y} = 3090$	$\frac{21,000}{(L_b S_x/I_y)}$
			8	$\frac{L_b S_x}{I_y} = 2750$	$21.1 - 0.25 \sqrt{\frac{L_b S_x}{I_y}}$	$\frac{L_b S_x}{I_y} = 3090$	$\frac{21,000}{(L_b S_x/I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges		18	$\frac{b}{t} = 6.9$	$25.4 - 1.07 \frac{b}{t}$	$\frac{b}{t} = 12$	$\frac{150}{(b/t)}$
	Flat plates with both edges supported		18	$\frac{b}{t} = 22$	$25.4 - 0.34 \frac{b}{t}$	$\frac{b}{t} = 38$	$\frac{480}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported		23	$\frac{b}{t} = 9.6$	$33.8 - 1.13 \frac{b}{t}$	$\frac{b}{t} = 20$	$\frac{4,500}{(b/t)^2}$
			10.5	---	10.5	$\frac{b}{t} = 21$	$\frac{4,500}{(b/t)^2}$
	Flat plates with both edges supported		23	$\frac{h}{t} = 49$	$33.8 - 0.22 \frac{h}{t}$	$\frac{h}{t} = 78$	$\frac{1,320}{(h/t)}$
			10.5	---	10.5	$\frac{h}{t} = 126$	$\frac{1,320}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported		23	$\frac{h}{t} = 115$	$33.8 - 0.094 \frac{h}{t}$	$\frac{h}{t} = 181$	$\frac{3,100}{(h/t)}$
			10.5	---	10.5	$\frac{h}{t} = 300$	$\frac{3,100}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs		20	11	$15.6 - 0.126 \frac{h}{t}$	$\frac{h}{t} = 82$	$\frac{35,000}{(h/t)^2}$
	Stiffened flat webs		21	11	$21.3 - 0.172 \frac{a_e}{t}$	$\frac{a_e}{t} = 82$	$\frac{48,000}{(a_e/t)^2}$
		$a_e = a_1 \sqrt{1 + 0.7(a_1/a_2)^2}$	4.6	---	4.6	$\frac{a_e}{t} = 102$	$\frac{48,000}{(a_e/t)^2}$

NONSHADED BARS

apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.

SHADED BARS

apply within 1.0 in. of a weld.

Type of Stress	Type of Member or Component	Spec. No.	Allowable Stress, ksi		Table A.5 Allowable Stresses for BRIDGE and Similar Type Structures* 6005-T5 Extrusions 6351-T5 Extrusions		
TENSION, axial, net section	Any tension member:	1	17				
TENSION IN BEAMS, extreme fiber, net section	Rectangular tubes, structural shapes bent about strong axis 	2	17				
	Round or oval tubes 	3	21				
	Rectangular bars, plates, shapes bent about weak axis 	4	25				
BEARING	On rivets and bolts	5	30				
	On flat surfaces and pins	6	20				
			Allowable Stress, ksi Slenderness $\leq S_1$	Slenderness Limit, S_1	Allowable Stress, ksi Slenderness Between S_1 and S_2	Slenderness Limit, S_2	Allowable Stress, ksi Slenderness $\geq S_2$
COMPRESSION IN COLUMNS, axial, gross section	All columns	7	17	$\frac{L}{r} = 8.0$	$17.9 - 0.112 \frac{L}{r}$	$\frac{L}{r} = 66$	$\frac{45,000}{(L/r)^2}$
COMPRESSION IN COMPONENTS OF COLUMNS, gross section	Outstanding flanges and legs 	8	17	$\frac{b}{t} = 5.0$	$20.5 - 0.70 \frac{b}{t}$	$\frac{b}{t} = 12$	$\frac{1,740}{(b/t)^2}$
	Flat plates with both edges supported 	9	17	$\frac{b}{t} = 16$	$20.5 - 0.22 \frac{b}{t}$	$\frac{b}{t} = 33$	$\frac{430}{(b/t)}$
	Curved plates supported on both edges, walls of round or oval tubes 	10	17	$\frac{R}{t} = 13$	$19.6 - 0.71 \sqrt{\frac{R}{t}}$	$\frac{R}{t} = 141$	$\frac{2,800}{(R/t) (1 + \sqrt{R/t/35})^2}$
COMPRESSION IN BEAMS, extreme fiber, gross section	Single web beams bent about strong axis 	11	19	$\frac{L_b}{r_y} = 21$	$21.3 - 0.111 \frac{L_b}{r_y}$	$\frac{L_b}{r_y} = 79$	$\frac{78,000}{(L_b/r_y)^2}$
	Round or oval tubes 	12	22	$\frac{R_b}{t} = 29$	$35.0 - 2.4 \sqrt{\frac{R_b}{t}}$	$\frac{R_b}{t} = 83$	Same as Specification No. 10
	Solid rectangular beams 	13	25	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 13$	$36.1 - 0.83 \frac{d}{t} \sqrt{\frac{L_b}{d}}$	$\frac{d}{t} \sqrt{\frac{L_b}{d}} = 29$	$\frac{10,200}{(d/t)^2 (L_b/d)}$
	Rectangular tubes and box sections 	14	19	$\frac{L_b S_x}{I_y} = 120$	$21.3 - 0.21 \sqrt{\frac{L_b S_x}{I_y}}$	$\frac{L_b S_x}{I_y} = 1700$	$\frac{21,000}{(L_b S_x/I_y)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under uniform compression), gross section	Outstanding flanges 	15	19	$\frac{b}{t} = 6.4$	$24.3 - 0.83 \frac{b}{t}$	$\frac{b}{t} = 10$	$\frac{162}{(b/t)}$
	Flat plates with both edges supported 	16	19	$\frac{b}{t} = 20$	$24.3 - 0.26 \frac{b}{t}$	$\frac{b}{t} = 33$	$\frac{520}{(b/t)}$
COMPRESSION IN COMPONENTS OF BEAMS, (component under bending in own plane), gross section	Flat plates with compression edge free, tension edge supported 	17	25	$\frac{b}{t} = 8.8$	$36.1 - 1.26 \frac{b}{t}$	$\frac{b}{t} = 19$	$\frac{4,400}{(b/t)^2}$
	Flat plates with both edges supported 	18	25	$\frac{h}{t} = 46$	$36.1 - 0.24 \frac{h}{t}$	$\frac{h}{t} = 75$	$\frac{1,350}{(h/t)}$
	Flat plates with horizontal stiffener, both edges supported 	19	25	$\frac{h}{t} = 107$	$36.1 - 0.104 \frac{h}{t}$	$\frac{h}{t} = 173$	$\frac{3,100}{(h/t)}$
SHEAR IN WEBS, gross section	Unstiffened flat webs 	20	11	$\frac{h}{t} = 33$	$13.9 - 0.089 \frac{h}{t}$	$\frac{h}{t} = 65$	$\frac{34,000}{(h/t)^2}$
	Stiffened flat webs  $a_e = a_1 / \sqrt{1 + 0.7(a_1/a_2)^2}$	21	11	---	11	$\frac{a_e}{t} = 65$	$\frac{47,000}{(a_e/t)^2}$

* Apply to nonwelded members and to welded members at locations farther than 1.0 in. from a weld.